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MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA.

THE RICE BUG.

(*LEPTOCORISA VARICORNIS*, FABR.)

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

AGRICULTURAL RESEARCH INSTITUTE, PUSA.

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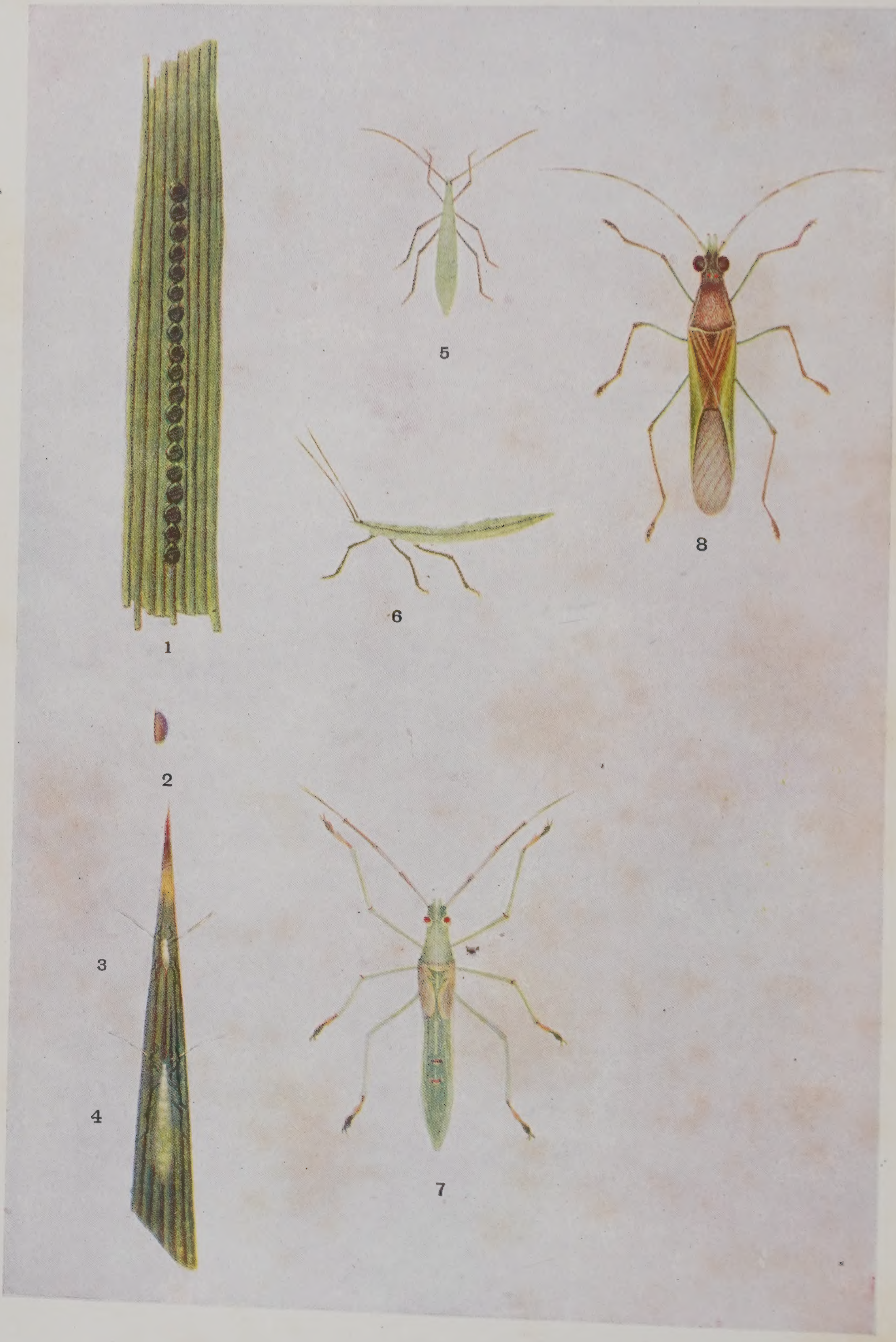
PLATE I.



RICE BUG

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I.—DESCRIPTION.

THE family *Coreidæ* belongs to the order *Rhynchota*, sub-order *Heteroptera*, division *Gymnocerata*, and is classed with *Berytidæ* as bugs in which the antennæ are inserted on the upper half of the head ; the rostrum is not curved at the base, the tarsi are three jointed, and the hemelytron has no cuneus. From the *Berytidæ* it is distinct in that the legs are not of great length with the femora dilated at the apices, and it follows the Pentatomidæ, in which the great development of the scutellum is the distinguishing feature. Distant, in the Fauna of India, enumerates 143 species from India, Burma and Ceylon, the majority of which are hill forms, while some thirty species form part of the Fauna of the plains of India proper. Of these, not more than six can be regarded as being of any economic importance ; undoubtedly the most destructive and important species is the Rice bug, *Leptocorisa varicornis*, Fabr.

The genus *Leptocorisa* is regarded by Distant as including three species, the distinctions between which are minute, concerned with colouring and with the structure of the upper surface of the prothorax. The colouring of these insects when alive is by no means the same as that found in a dried pinned specimen preserved in an atmosphere saturated with napthalin ; the green tint fades to a dull yellow brown and the intensity of fuscous and other dark shades depends very largely upon the freshness of the specimen and

its preservation. If we reject colouring as a specific diagnostic, we have length, the presence or absence of a small tubercle near each lateral pronotal angle and of a distinct central carinate line on the pronotum.

An examination of several hundred specimens pinned within the past four years shows a considerable amount of variation in respect of the two last characters ; we have been unable to separate out definitely any series of specimens as belonging to either *Leptocorisa acuta*, Thunb., or *L. costalis*, Herr. Sch., from all the specimens reported as injurious during the past four years ; from those collected during that time and now in the Pusa collection, we have what may be *L. acuta* only from one locality in India, Chapra (Mackenzie collection) and from the Khasia Hills ; and with the single exception of a large series of specimens sent from Burma, which are apparently *L. acuta*, Thunb., we have treated the injurious forms of India proper as being all one species ; for reference we reprint below Mr. Distant's diagnosis of the three species ; *L. acuta*, Thunb., is recorded from Bengal on the authority of Westwood who describes it as *L. bengalensis*, and from Calcutta on the evidence of specimens sent to Mr. Distant by the Indian Museum. *L. costalis*, Herr. Sch., is Burmese. It is probable that the minute differences which constitute these as separate species does not imply any difference in the life history.

667. *Leptocorisa varicornis*, Fabr.

Ochraceous ; above somewhat thickly punctate ; eyes black ; membrane pale, colourless, hyaline ; basal joint of antennæ ochraceous ; second, third, and fourth joints fuscous with their bases luteous ; first and fourth joints longest and sub-equal in length, second and third shortest and sub-equal ; sternum very coarsely punctate ; rostrum reaching the intermediate coxæ, its apex piceous ; abdomen above testaceous.

Length 15 to 17 millim.

668. *Leptocorisa acuta*, Thunb. (Cimex), Nov. Ins. Sp. ii, p. 34 (1783) ; Dist. P. Z. S., 1901, i, p. 331.

Above brownish-olivaceous ; beneath pale greenish ; abdomen above reddish-brown, with the margins pale greenish-yellow ;

antennæ fuscous, bases of second, third, and fourth joints luteous; above, with sternum beneath, thickly and coarsely punctate; a small distinct tubercle near each lateral pronotal angle; a distinct central carinate line to pronotum.

Length 13 to 15 millim.

669. *Leptocorisa costalis*, Herr. Sch. (Myodochus) Wanz. Ins. vii., p. 96, f. 864 (1848).

Ochraceous; antennæ, basal lateral margins of head, small tubercle near lateral angles of pronotum, clavus and inner area of corium black; base and apex of apical joint of antennæ luteous; legs ochraceous; tibiæ, tarsi, and apices of femora fuscous; body above and sternum beneath coarsely punctate.

Length 15 to 18 millim.

Distribution.

The following is a list of localities from which this pest is definitely recorded:—

Naini Tal.	Bankura.		Dacca.	
Dehra Dun.	Calcutta.		Comilla.	
Partabgarh.	Burdwan.		Munshiganj.	
Pusa.	Orissa.		Balasore.	
Chapra.	Sylhet.		Tinnevelly.	
Birbhum.	Sikkim.		Bangalore.	
Hazaribagh.	Shillong.		Karwar.	
Ranchi.	Tennasserim.		Karachi.	
Murshidabad.	Mergui.		Lonawla.	
Bettiah.	Khasi Hills.		Sind.	
Santhal Pergunnahs.	Palon	Burma.	Nagpur	Central Provinces.
Rangpur.	Bhamo		Bhandara	
Hathwa.	Katha		Balaghat	
Palamau.	Karennee		Bilaspore	

This practically covers the sub-montane and rice areas of United Provinces and Behar, Lower Bengal, Assam, Burma, Orissa, the rice areas of Central Provinces, Malabar, and the West coast and Karachi. That is, the bug occurs in the moister sub-montane and plains areas of India and Burma, exclusive of dry and desert areas.

Habits and Life History.

Leptocorisa varicornis occurs commonly in long grass and in thick vegetation at all times of the year. The slender form and

the dull green colour of the adult render it inconspicuous ; but, on approaching it, it takes to the wing and flies off rapidly. It is in no sense a gregarious insect and one finds it here and there singly, or one sees a number fly out together from a grass border when they are specially abundant. They are diurnal insects, active in the morning and evening, going deep into shelter in the hot part of the day. Like their allies, they diffuse an odour of an aromatic and penetrating character ; this is probably primarily defensive and it is often possible to discern an infested rice field simply by the smell. The bugs feed upon the sap of the flowering shoots of grasses ; they may be seen in long grass at all times but their chief food is derived from the flowering stems which grow up and in which there is an abundant flow of sap. In the coarser grasses such as rice, the individual grains are large enough to afford food to them and they feed on the tender developing grain full of milky juice.

Eggs.—The eggs may be found in clusters on the leaves ; the clusters consist of one, two or three rows of eggs laid neatly and symmetrically. The eggs are usually in one row, numbering from five to twenty. Each egg is oval in outline, flattened, slightly concave above ; its length is about one millimetre, its breadth about $\frac{3}{4}$ m.m. (Plate I, fig. 2). The shell is hard, dark brown and its outer surface roughened as if the gummy matter with which the eggs are covered had dried in this manner. Each egg has a white spot at one end, marking the point at which the shell ruptures.

The long axis of the egg is usually parallel with the direction of the row of eggs ; the general appearance of a cluster is that of a row of small leguminous seeds (Plate I, fig. 1). The eggs are firmly fixed to the leaf by a gummy matter which covers the eggs as they are laid and which rapidly hardens. The heavy monsoon rains do not affect the eggs laid openly on the leaves of rice or millets.

Eggs are apparently laid at night ; only in captivity has the process been witnessed and, though coupling can be seen in the field constantly, egg-laying has not been. The number of eggs laid is from 24 to 30 ; it has not been possible to ascertain this from observation but from dissection of mature fertilised females. While the eggs of one cluster hatch at about the same time, the period

varies for different clusters. From six to eight days is the time that elapses between the laying of the eggs and the emergence of the young.

The egg opens by a nearly circular piece breaking off on the flat upper surface at the end where is the white spot. This piece that breaks has a distinct "fracture," and is not regular. When it has come off the nymph emerges from the amnion which it leaves behind ; this fracture of the shell is curious and it has taken some care to arrive at an explanation of the phenomenon ; the embryo is formed in the egg with the head at the end of the egg which opens ; the vertex of the head is immediately under the centre of the piece that breaks and it is at one point more densely chitinised ; the dorsal surface of the embryo fits the curve of the egg below the white spot, the legs, antennæ and rostrum pass along the flat surface of the egg to the opposite pole ; exactly how pressure is exerted is not clear, but apparently pressure is exerted at the vertex of the head, forcing off the "lid," and allowing the skin of the back of the head and dorsum of the thorax to split ; the little nymph then wriggles out, the limbs are drawn from the enveloping skin which remains behind.

Nymph.—From the emergence from the egg to the attainment of maturity, the nymph passes through five stages, marked by gradual development of wings, by increase in size, and by the small colour changes ; the final moult is also marked by the transfer of functional odoriferous glands from the abdomen to the thorax, the development of the external genital appendages, and the formation of the third tarsal joint. The nymphal stage occupied in the insectary 15 to 18 days ; the following table gives the dates recorded in the insectary for each moult in the case of five individuals :—

Hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.	Duration of nymphal stage in days.
Length 2 m. m.	5 m. m.	7 m. m.	11 m. m.	14 m. m.	15 m. m.	
28-VIII	2-IX	4-IX	6-IX	8-IX	14-IX	17
28-VIII	2-IX	4-IX	6-IX	8-IX	15-IX	18
30-VIII	3-IX	4-IX	7-IX	10-IX	15-IX	16
2 IX	4-IX	6-IX	8-IX	11-IX	17-IX	15
2-IX	4-IX	6-IX	9-IX	12-IX	18-IX	16

On hatching, the bug is about two millimetres long ($\frac{1}{12}$ inch): the legs, antennæ and beak are of comparatively enormous size; the legs are fuscous with two jointed tarsi, the antennæ four jointed, red brown with two lighter bands, the proboscis four jointed, fuscous, and extending between the legs to the apex of the abdomen. The body is green, and is held in a curve, the head and apex of abdomen raised from the leaf. The apertures of the odoriferous glands are very small and inconspicuous, on the junction of the second and third and third and fourth abdominal segments above, the glands being apparently functional soon after hatching. The body and legs bear numerous dark hairs which are relatively long and may be of assistance in the emergence from the egg.

In the second instar, the length increases to 5 millimetres ($\frac{1}{5}$ inch), the body retains its green colour but grows larger in proportion to the legs and antennæ, the rostrum now reaching only to the hind coxæ. The fuscous of the legs and antennæ is replaced by reddish brown.

After the second moult, the length is increased to seven millimetres and the apertures of the odoriferous glands on the dorsum of the abdomen become more apparent.

After the third, these apertures become still more pronounced, the wing lobes become visible on the meso and meta-thorax, and the length increases to eleven millimetres. With the next moult the length is 14 millimetres, the wing lobes increase in size, the colour of the legs becomes paler. Finally, there is the last moult (the fifth), when the fully winged insect appears (see Plate I, figs. 3—7).

Moults are undertaken with apparent difficulty in each instar and the bug is at the time very helpless: the skin bursts along the prothorax above, the delicate young insect struggling through this aperture. A curious feature of the exuvium is the comparatively large chitinous vessels in the abdomen firmly attached to the dorsal integument at the odoriferous apertures, and which are presumably the reservoirs of the oil which the insect prepares for its defence. In the final moult, these glands give place to the metathoracic glands, though the position of the former apertures

of the dorsal abdominal glands is marked in the adult by the thin integument and light mark. A feature of the metamorphosis is the formation of the third tarsal joint at the last moult.

The young feed on the juice of the leaves, stems and seeds of the same plants as their parents and are found in the same places; they are less easily seen on account of their colouring; they are less often found on exposed portions of the plant and they drop readily to the ground if alarmed. The imago lives apparently for a considerable time and the imaginal life is of far greater importance than the nymphal. At any time there are a far greater proportion of adults in the fields than nymphs, pointing to a greater duration in the imaginal life; and whereas the nymphal life occupies less than 20 days in captivity, adults were maintained alive for three months in captivity with insufficient food. From a batch of eggs that hatched on the 2nd September, adults were reared on the 18th and lived until the 2nd November with abundant food. Males and females are alike in size, colouring and general appearance; the male has the abdomen slightly swollen at the apex, the female has the base and middle of the abdomen larger. Coupling takes place, as in all Heteroptera, in opposition.

Enemies.—Two insects are definitely known to attack this pest: *Cicindela sexpunctata*, Linn., is abundant in infested fields from August to October; it flies actively and destroys the bugs in numbers.

Another check on the bug is an egg-parasite, which has been reared from eggs found in the field; this is an apparently undescribed species; it has not been found to occur in great number.

Occurrence throughout the year.—Under ordinary circumstances during warm weather, the complete life cycle occupies from four to five weeks if there is abundant food; on the Pusa Farm, the bugs breed freely from the middle of July, on the ripening marua (*Eleusine coracana*) first, then on grasses, rice and Sama; there are apparently five broods during the rainy months and subsequent warm weather, depending, however, upon the food supply, which is apparently usually ample once the marua commences to form grain in July. After the cold commences in December, the rice

bug disappears from the fields but is found in dense grass and in the jungly growth of uncultivated land. Only adults have been found and there has been nothing to show that it breeds at all until the following rains. It can be found, in small numbers, and, in places such as Pusa, where there are three well-marked seasons, we may say that, normally it breeds freely from July to November (both inclusive), that it hibernates as an imago from December to February, and that it æstivates from March to June; there is no reason to believe that it will not breed during the latter period if food be available, but up to the present it has not been found to do so until the *marua* forms grain in July.

The above is probably true of the greater part of India with variations in the dates for different localities. So far as the pest affects crops, we would find it breeding whenever a crop of rice or millet was forming grain, in whatever month that might be.

In Pusa, the most severe attack is in October—November, when the pest has had time to multiply. So far as has been seen in four years' observation of this insect, only a comparatively small number survive the prolonged periods of hibernation and æstivation; these start breeding in July, multiply gradually and with the ripening of the Sama in September, are in fair number; from then on their number gets greater in the rice till it reaches its maximum in October—November. This is probably the case elsewhere and all reports of attacks come late in the breeding season when the pest has been multiplying for some time.

Damage to Crops.—All previous records and all official reports relate to damage to rice, in almost every case when the grain was forming and the seeds are full of milky juice. This form of damage may be constantly observed to a greater or less extent in rice fields probably every year. The bugs fasten on the rice ears and suck out seed after seed; such ears turn wholly or partly white, little or no grain being formed. A field badly infested can be detected by the number of these white ears, but one can readily confuse this form of damage with that caused by stem borers; in the latter case the whole stalk and ear withers from below; in the former only the grains die and the ear is empty but the stalk quite sound. We have

also observed similar damage to Sama (*Panicum frumentaceum*) and to Marua (*Eleusine coracana*). In these cases the loss is probably not sufficiently great to be noticed or reported. Other food plants are Juar (*Andropogon sorghum*), Bajra (*Pennisetum typhoideum*), and Kangni (*Setaria llitalica*). The following cases are recorded in Indian Museum Notes and elsewhere or have been reported officially during the past four years. We have taken all records to apply to this species, though the insect is called *L. bengalensis*, as well as *L. acuta*, in the older records.

H. Mathewson, Esquire, reports it as "decimating the rice crop in Manbhum," in September 1898 (Letter to Reporter on Economic Products). In an article in Indian Museum Notes, Vol. I., No. 1, E. T. Atkinson states that it was reported from Tinnevelly in 1886, as "found to have considerably injured the autumn rice." It had been also reported from Bankura, where it had "damaged the early rice crop when ripening (September)"; seedling paddy is reported to have been attacked (Proc. Agri-Horticultural Society, 18th May 1871); it is recorded from Partabgarh in Oudh; the Deputy Commissioner, Hazaribagh, reported it as "attacking the gori and badhoi rice while in the ear; it destroys up to three-fourths of the crop and generally appears in a year when the rains set in early (May)." In a later number of Indian Museum Notes, are further references to it (Vol. I., No. 4, p. 205), the Sub-Divisional Officer, Karimganj, Sylhet, reporting as follows: "The insects attack only murali and aus dhan, about the months of July and August." The Deputy Commissioner of Sylhet also sent the pest, stating that it did damage in the latter part of the rains. In Champaran, the pest was found by Mr. T. Cripps to attack the bhadoi paddy in September (Ind. Mus. Notes, II, p. 35). It is also recorded as a pest in Balasore (loc. cit. III, 5, p. 56), in Angul, Orissa (loc. cit. IV, p. 26), in Backergunj, Malabar, Cuttack, Ganjam and Bhola, (loc. cit., IV, p. 121) and Bettiah (l. c. V, p. 24).

In September 1904, the Mamlatdar of Karwar, Kanara, reported it; in Dehra Dun, it is stated that infested fields have such a smell that not even cattle will eat rice affected by it and pigs avoid fields in which it has settled. "The popular account of its origin is that

it sprang from an elephant which was killed in a kheddah ten years ago. It is said to stop in the jungles during the cold weather and hot weather and only come out into the fields during the rains when the forests get too wet for it.'

Naini Tal is also reported as an infested district, a loss of 25 per cent. being caused in September 1904 in 20 villages. (Letter from J. G. Faunthorpe, Esquire, I.C.S., Collector of Naini Tal). A similar report came from Noakhali in 1906 (letter from A. H. Clayton, Esquire, I.C.S., Collector of Noakhali). At the same time (October 1906), damage was reported from Cox's Bazaar (letter from Babu Tara Prasanna Acharya, Sub-Divisional Officer, Cox's Bazaar) and from Birbhum (letter from W. Val Weston, Esquire, Manager, Gonatea Division, Bengal Silk Co., Ltd.).

It was reported from Champaran in 1907 by W. Gourlay, Esq., Collector of Champaran.

The above reports show that the pest is injurious to ripening paddy in a large area of India; nearly all are dated in September—October, when the rice crop matures in Northern India, while in Malabar and South India generally, the pest is found during the warm moist months, November and December.

Treatment.—The reports say little about any methods of treatment, and it is probably true that, as a rule, none are adopted but the use of *mantras* or other invocations of supernatural means. A note on this pest in the Ceylon *Observer* of 4th November 1889, quoted in Indian Museum Notes, I, p. 205, mentions other methods. "*Smoking* by burning certain aromatic herbs and resinous substances to windward very often attended with great success." Other writers have suggested this remedy, but we are not aware that it has been experimentally tried. In Pusa, trials of this method showed that small areas could be cleared and that the bug went to other fields or to neighbouring grass; but the method is a temporary one and must be carried out for the time the rice grain is hardening. We have, after trial, abandoned this method.

"Ropes saturated with resin oil or kerosene oil are drawn over the fields with doubtful success." This method is now in use in Malabar; H. C. Sampson, Esquire, Deputy Director of Agriculture,

Madras, forwarded a report showing that a long thin coir rope is dipped in the liquid fat of cod-fish, *i.e.*, in fish-oil, and drawn through the field brushing the ears of paddy. In consequence of this treatment the insects are said to leave the field. Fish-oil is not readily procured except in South India and near the Coast, so the remedy is not generally applicable.

The third method as in use in Ceylon is thus described :—"A paddy winnow is taken and a glutinous substance, generally the milk of the jack (*Artocarpus incisa*), is rubbed on the inside. This is tied to a long pole and the ears of paddy are brushed with it, when the insects are found adhering in large numbers. The winnow is held over a fire and the insects killed. The process is repeated over and over again." This method is the equivalent of the ordinary hand net system and very tedious in operation. It is, however, simple and within the reach of the cultivator if he will take this amount of trouble.

A careful study of this pest and repeated practical attempts to rid the rice cultivation on the Pusa Farm of it, has led to the adoption of a modification of the South Indian methods. We use the elongated bag, open at one side, which is run through the field brushing the upper third of the plant and sweeping in the bugs as they rise ; this bag is either coated inside with some sticky material (we use Crude Oil Emulsion), is soaked in a strong solution of Crude Oil Emulsion (1 pint in 2 gallons of water) or, at the end of each run it is twisted up quickly and the bugs it contains crushed. This form of bag has been fully described in Indian Insect Pests. We use one with an opening of approximately eight feet wide by three feet high, the sides kept open by two bamboos three feet long which serve as handles to grasp the bag with ; the bag is three feet deep. This width is about as much as two ordinary coolies can run with. An advantage in the system is that the predaceous beetle (*Cicindela sexpunctata*, Linn.) is not destroyed, as it is far too agile to be captured by such means.

We question whether any other method will be found, and we would recommend such of the methods described as suit local circumstances, with a strong recommendation that the last is by far

the most effectual where either co-operation between small cultivators can be arranged or where large areas can be treated together. It naturally does not pay to spend money on a cloth bag if the area involved is only an acre or two. C. S. Misra, first assistant, noticed that the bugs collected on young juar stalks that had been chewed by jackals; we have noticed the same thing with broken sugarcane and in each case the bug apparently feeds upon the sweet sap. The same occurs if a mixture of bran (2 seers) and *gur* (2 chittacks) are mixed together, the bugs congregating upon the mixture and being there readily captured.

Before leaving this question we may draw attention to some other points. When more is generally known of insect pests, it will be more widely realised that in dealing with destructive insects, there are no short cuts to success, no magical means whereby a field can be freed of insects; it is as much trouble to do it as it is to eradicate weeds, and it is useless expecting that any scientific study will produce any such magical means, without the corresponding machinery. In a country such as India, where we come down to the "bed-rock" of simple agriculture without any but home-made appliances, methods of checking pests can only utilise equally simple methods. In this case, the careful study of the pest elicits the following facts, which are the gist of the matter for ryots growing rice in infested areas:—

The rice bug is found in the field when the rice is coming into ear and for some time before; it flies in from jungle, scrub, long grass and similar places or from fields of millet such as Sama and Marua; those that fly in lay eggs and die after a time; the eggs are laid in rows on the leaf, are like little black seeds and hatch in about a week; the insect that comes out of the egg is a miniature bug, only without wings, and in about 18 days, during which time it feeds hard, it becomes winged and flies; it is then either male or female, and, after mating, the female lays about 24 eggs. It then dies. From the time it leaves the egg until it dies, the insect lives by sucking the sap of the plant or the milky juice of the grain;

therefore, from one couple that fly in, there will, in one month, be about 24, in two about 288 and so on, if none die. Ordinarily a number die or are eaten, and in some years, so few escape that no injury is done ; but in some seasons, the bugs become more and more numerous and especially destroy the rice in the ear. It is evidently wise to destroy them if they are in the field *before the rice comes into ear ;* a cultivator who knows the insect and its eggs, and who watches his crop, will see the bugs or smell them, and will destroy them and their eggs.

The chief enemy of this insect is a beetle which flies about in the rice fields and eats the bugs ; this should not be destroyed.

This seems to embody the practical information derived from this investigation ; we have devised no novel "cure-all" method that will check this pest ; we have accurate knowledge about the pest, we deduce and try such methods as seem useful, we know that a number of methods that might be good are useless (now that we know the life history), and it is open to any one with a local knowledge of agriculture to use the same knowledge and deduce suitable methods.

Explanation of Plate I.

(1) Eggs as laid on the leaf	× 3
(2) One egg from the side	× 6
(3) Just-hatched nymph	× 3
(4) Nymph in the second stage	× 3
(5) Nymph in the third stage	× 3
(6) Nymph in the 4th stage	× 3
(7) Nymph in the 5th stage	× 3
(8) Adult	× 3

REMARKS ON INDIAN SCALE INSECTS (COCCIDÆ), PART III.

WITH A CATALOGUE OF ALL SPECIES HITHERTO RECORDED FROM THE INDIAN CONTINENT.

By E. E. GREEN, F.E.S., F.Z.S.,

Govt. Entomologist, Ceylon (with original Illustrations by the author).

The following notes are in continuation of a series commenced in the now defunct publication 'Indian Museum Notes.' Part I appeared in Vol. V, No. 1, and Part II in No. 2 of the same volume. The present paper constitutes Part III of the series, and besides recording several species hitherto known only from other countries, describes eighteen species new to science and two new varieties. As the total number of recorded species has now reached the century, a complete catalogue of the Coccidæ of the Indian Continent is appended. I have not attempted to give all the citations for each species, but have contented myself with supplying a reference to the original description and to such others as have appeared in Indian publications. Where no reference is given, the species is noticed or described for the first time in the present paper. To make the list as complete as possible, I have included four species which are as yet undescribed. The descriptions will appear in my monograph on the Coccidæ of Ceylon. They must for the present remain '*nomina nuda.*'

With regard to the nomenclature, there have recently been some very revolutionary changes in generic names. If these were merely new names, this would not be of much consequence; but much confusion has resulted from a general shuffling of the

older and most well established names. For instance, *Coccus*, which we have associated for so many years with the cochineal insects, is now made to take the place of *Lecanium* (another old friend); while *Dactylopius*—by which name we have always known the 'mealy bugs'—is shifted to cover the nakedness of the cochineal insect (bereft of its more familiar name). Similarly, *Pseudococcus* has been moved on a place and now represents the common mealy bugs. There are other alterations too numerous to mention. As this rearrangement is still somewhat controversial, in the present paper I have retained most of the more familiar names. To those who have wholeheartedly adopted the newer nomenclature, the following alterations will be necessary :—

For *Dactylopius*, read *Pseudococcus ;*
,, *Coccus*, ,, *Dactylopius ;*
,, *Lecanium*, ,, *Coccus ;*
,, *Mytilaspis*, ,, *Lepidosaphes.*

Monophlebus Stebbingi (Green).

Mr. Stebbing sends me a mass of cottony matter intermingled with exuviæ and fragments of male insects. This material was found in a crevice of the bark of *Shorea*, and probably covered the male pupæ.

The eggs are deposited in a mass of white cottony substance. Colour orange red. Rounded at one end and obliquely pointed at the other extremity. Length 0·9 mm.

Monophlebus Stebbingi, var. Octocaudata, nov.

Adult male as in type.

Adult male differs in having 4 (instead of 3) fleshy tassels on each side of the abdomen. The uppermost tassel is short and may be reduced to little more than a prominent tubercle. Halteres with from 6 to 9 hooked bristles. Legs blackish, tinged with reddish brown on tarsi. Other characters as in type.

Length, exclusive of appendages, 4 to 5·50 mm. Expanse 10 mm.

On Mango : Shalimar Gardens, Lahore.

Differs from male of *Dalbergiæ* (which also has 8 appendages) in its much smaller size.

Monophlebus Tamarindus, nov.

Adult female differs from both *Dalbergiæ* and *stebbingi* in the much shorter hairs of the derm, and in the smaller glandular pores of the skin. Antennæ smaller and more slender. Length 14 mm. Breadth 8 mm.

On branches of 'Tamarind :' Agra.

N.B.—The dimensions of the female insect cannot be accepted as a specific character. In the first place, the examples may not be fully grown, though sexually mature ; and secondly, the size will probably vary with the nature of the food plant. The size of the male is more constant.

Icerya Minor, nov.

Adult female with short, stout, opaque white, waxy processes, arranged symmetrically in median dorsal, dorso-lateral, and marginal series. Body purplish above, yellowish orange beneath. Ovisac covering the ventral area of abdomen. Eyes prominent, conspicuous. Antenna ochreous brown, 10-jointed, 10th longest, equal to previous two together ; 2nd and 3rd next longest, equal, cylindrical ; 4th to 9th somewhat globose, sub-equal. Legs ochreous brown, moderately stout ; tibia equal to femur and trochanter combined, (slightly longer in hind limb) ; tarsus approximately half length of tibia, strongly curved : tarsal digitules simple, pointed ; ungual digitules, knobbed. Derm with numerous stout hairs, each arising from a stout collared tubercle, longer and more crowded on the marginal area and round the anal aperture. Three well defined subcircular scars (Fig. 1) on venter near posterior extremity (as in *Walkeriana*). Derm of both dorsum and venter with numerous circular spinnerets varying in diameter from ·005 to ·010 mm., more crowded on marginal area,

each with an obscurely trilobate central aperture and a beaded rim. Length 3·25 to 6 mm. Breadth 2·50 to 4·50 mm.

Nymph (as shown by exuviæ) covered with stout curling filaments, those on the disc of dorsum closely recurved towards the centre.

Male pupa orange yellow; concealed in a slight puparium beneath masses of loose woolly secretion.

Adult male reddish brown; lateral margins of abdomen yellowish. Eyes large, coarsely facetted. Wings ample. Antenna 10-jointed, each joint (except the first) binodose and with two whorls of very long hairs. Halteres each with 4 stout curved bristles. Extremity with a stout fleshy process on each side, bearing from 4 to 5 long stout hairs on its rounded apex and numerous shorter hairs below. Length 2·50 mm. Expanse of wings 4·50 mm.

Young larva bright yellow, with some patches of white mealy wax on the dorsum. Eggs yellow.

On Mango: Pusa, Bengal. Coll., H. M. Lefroy.

Considerably smaller than *I. ægyptiaca*, and differing in having ochreous brown (instead of black) limbs.

Icerya Pilosa (Green).

On Spinifex squarrosus: Madras. Coll., Mrs. Lilian Taylor.

Icerya Seychellarum (Westw.).

On Casuarina. Coll., E. P. Stebbing.

The waxy covering of this insect may vary from gamboge yellow to almost white. But the species may be readily recognized by the very large ring-like spinnerets scattered amongst the smaller glandular pores on the derm. These rings have a boldly beaded rim and a diameter averaging ·02 mm.

Walkeriana Cinerea (Green), nom. nud.

A single half grown example on *Acacia arabica*: Surat. Coll., H. M. Lefroy.

WALKERIANA POLEI (Green).

On undetermined plant : S. India. Coll., C. A. Barber.

PERISSOPNEUMON FEROX (Newstead).

In nests of *Œcophylla smaragdina* : N. Konkan (Accidentally omitted from previous lists.)

ASTEROLECANIUM GRANDE (Newstead).

On "a grass-like plant :" Baluchistan. (Accidentally omitted from previous lists.)

ASTEROLECANIUM MILIARIS ROBUSTA (n. var.)

Altogether larger and comparatively broader than type. Length 1·10 mm. Breadth 0·60 mm.

On stems of Bamboo : Pusa, Bengal. Coll., H. M. Lefroy.

CEROCOCCUS HIBISCI (nov.).

Female insect covered by a compact *test* which varies considerably in colour and texture ; this variation being apparently due partly to age (and consequent detrition) and partly to differing food plants. Some examples (Fig. 2) on the young shoots of *Hibiscus liliiflorum* are thickly coated with a pinkish red tomentum from which projects many tufts of coarse glassy filaments. This appears to be an early stage in the development of the test. In this stage, the covering is only weakly coherent and the insect has the characters of *Antecerococcus.* Older examples from *Hibiscus* and from *Gossypium* (Fig. 3) have a more compact corneous globular test of a dull brownish colour, with a superimposed scurfy covering of yellowish secretion, above which, again, may be found traces of the original pinkish tomentum and glassy filaments. At the posterior extremity is a short tubular extension of the test. In another series of examples from *Gossypium* the globular test is thickly coated with a bright

golden yellow scurfy tomentum, without any tufts of filaments. Without the intermediate series, it would have been difficult to connect these two extreme forms. The structure of the insect itself is identical in all the different forms. Length of mature test 2·50 to 3·50 mm. Breadth 2 to 2·59 mm.

Male puparium oblong, with rounded extremities ; coated with a scurfy tomentum which varies in colour from pinkish to bright yellow. Fresh examples with tufts of glassy filaments. Posterior extremity with a large circular orifice covered by a corneous operculum. Length 1 mm. Breadth 0·50 mm.

Adult female (Fig. 4) broadly pyriform, abdominal segments narrowed and tapering to the posterior extremity. Terminal segment with two irregular prominent conical tubercles, each with a long stout hair at its apex, one or two stout curved spines on its inner margin, and several shorter stout hairs. A median dorsal rounded or subtriangular plate at base of tubercles, surrounded by a more or less well defined chitinous area which extends along the inner edge of the tubercles. Antenna rudimentary, consisting of a single cylindrical truncate joint, surmounted by five or six stout hairs. Sometimes two joints can be distinguished. Limbs rudimentary, each consisting merely of a stout conical spine with a broadly expanded cupola-shaped base, the first pair considerably smaller than the other two. Spiracles moderately large and conspicuous : each with a small group of parastigmatic glands. Anal ring with eight long stout hairs which extend almost to the extremity of the anal tubercles, and a pair of similar hairs on the venter immediately anterior to the ring. Dorsum thickly studded with conspicuous 8-shaped pores, of two sizes, the smaller less than half the size of the larger. Similar pores, of the smaller size, on the venter of abdominal segments. Two groups of large conspicuous circular cribriform plates on the dorsal surface of the abdomen, from 3 to 6 in each group ; sometimes in pairs. This last arrangement appears to be constant in the bright yellow form, but will scarcely constitute a specific character. Length 1·50 to 2·75 mm. Breadth 1·25 to 2·25 mm.

Habitat.—On branches of *Hibiscus*, Bombay; and *Gossypium*: Pusa, Bengal. Coll., H. M. Lefroy.

Lefroyia (Gen. nov.).

Adult female enclosed in a felted or waxy sac. Anal tubercles small, obscure, attached to a chitinous plate closely surrounding the setiferous anal ring, which is not at the extremity of the body but at the base of a cleft somewhat resembling that of *Lecanium*. Legs and antennæ present. Derm densely chitinous with compound spinnerets.

Immature stages unknown.

Differs from *Eriococcus* in the withdrawal of the terminal segment and the anal tubercles into a deep cleft.

The genus is dedicated to Mr. H. M. Lefroy, Entomologist to the Indian Government.

Type *Lefroyia castaneæ*.

Lefroyia Castaneæ (nov.).

Adult female with a close white covering of mingled felted and waxy matter; very thick and dense at the sides; thin on the dorsum which is sometimes partly exposed (Fig. 5). The covering fits close against the insect, but can be peeled away from it.

Denuded insect (Fig. 6) bright castaneous; densely chitinous; oval, strongly convex above; posterior extremity with a deep cleft to the anal aperture. Antennæ rather small; at some distance from the margin, on the ventral surface; 7-jointed, 3rd longest (equal to 4th, 5th and 6th together), 6th and 7th sometimes fused. Mentum apparently monomerous. Eyes obsolete. Legs comparatively small; femur short and thick; tibia long and slender, longer than femur and trochanter together; tarsus often with a deep median indentation which gives it the appearance of being 2-jointed; claw slender, pointed, almost straight; digitules dilated at extremity. Anal ring broad, with numerous large translucent pores and six longish stout

hairs (Fig. 7). An irregular outer chitinous ring or plate, supporting, on each side, a small rugged prominent tubercle surmounted by several stout spines. Derm of dorsum closely studded with small circular compound pores, each with five orifices (Fig. 8) arranged in a compact rosette. Anal aperture surrounded by a denser chitinous area with numerous translucent spots. Length 4·50 to 5·50 mm. Breadth 3 to 3·50 mm. Size of test varying from 5 by 4 to 8·50 by 7·50 mm.

Other stages unknown.

Habitat.—On the smaller branches of *Castanea* sp.: Shillong, Assam. Coll., H. M. Lefroy.

I was at first extremely puzzled in determining the position of this aberrant insect. The denuded female has a distinctly Lecaniid facies, with its hard, smooth, chitinous derm and cleft posterior extremity. The absence of stigmatic clefts or spines, and the peculiar armature of the anal aperture showed that this similarity was merely superficial. The later discovery of the obscure anal tubercles suggested its affinity to the genus *Eriococcus.*

Dactylopius Bromeliæ (Bouch.).

Doubtfully determined by Maskell, from examples said to injure mulberry trees in Berhampore. (See Ind. Mus. Notes, Vol. III, No. 5, p. 51.)

Dactylopius citri (Risso.).

On Coffee: Mysore. Coll., H. M. Lefroy.

The species determined by Atkinson as *D. adonidum* (Ind. Mus. Notes, Vol. I, p. 6) should have been attributed to *Citri.*

D. adonidum, Geoff., is now considered to be a synonym of *longispinus*, Targ., a species that has not yet been recorded from the Indian continent.

Dactylopius formiceticola (Newst.).

Matheram Hill, N. Konkan.

Accidentally omitted from previous lists.

DACTYLOPIUS NIPÆ (Mask.)

On Cotton (*Gossypium*), and on tubers of Potato: Bengal. Coll., H. M. Lefroy. Said to be a serious pest of stored seed potatoes.

Maskell described typical *D. nipæ* as having both 7 and 8-jointed antennæ. But specimens of the material originally supplied to him (received through Mr. R. Newstead), show 7-jointed antennæ only. These Indian examples agree in every other character with the type and with named material received from the Hawaiian Islands. I notice that the small dermal pores (described by Maskell as circular) are obscurely trilobed. In fresh uninjured examples, the dorsum is thinly clothed with mealy secretion and has, on each segment, a well-defined transverse series of four or five stout, waxy tufts, which give the insect a very characteristic appearance. The anal tubercles have each a single stout, whip-like hair and two stout, sharply pointed spines. The eyes (in mounted specimens) are well defined and contain a slightly pigmented median spot.

Examples on potato tubers are collected into more or less globular clusters at the 'eyes.'

DACTYLOPIUS SACCHARI (Ckll.)

This species has 7-jointed antennæ in the type. I find an occasional example in which one or both antennæ become 8-jointed by a sub-division of the normal 3rd joint.

DACTYLOPIUS SACCHARIFOLII (nov.).

Adult female elongate oval. Thinly covered with fine white mealy secretion. Margin with a fringe of delicate white waxy filaments, longest at posterior extremity. Abdominal segments not conspicuously demarked at the margins. A pair of moderately prominent rounded tubercles on the terminal segment; each bearing two longish hairs (one of which is considerably stouter than the other) and several shorter hairs; also a group of about eight stout pointed spines. Other segments (both abdominal and

thoracic), each with a submarginal dorsal prominence, bearing from 4 to 6 similar spines. Derm of upper surface with numerous small obscurely trilobed glandular pores, which are especially crowded on the submarginal prominences. Under surface of last five abdominal segments, densely crowded with larger circular thick-rimmed pores, which are replaced on the basal abdominal and thoracic segments by similar but smaller and more scattered pores. The whole of the undersurface with numerous stout hairs. Eyes prominent, conspicuous. Antennæ slender, the basal joint stouter; 8-jointed, the 8th always longest (longer than the following two together), 1st and 2nd next longest and approximately equal. Legs long and slender; tibia almost equal to femur and trochanter; a row of stout spiniform hairs along the inner edge of each joint; tarsus less than half length of tibia; digitules hair-like. Anal ring with 8 hairs, of which 2 are small and inconspicuous. Length 4·50 to 5·25 mm. Breadth 1·75 mm.

During oviposition a narrow elongate ovisac is formed, after which the insect itself falls off and is lost. The ovisac alone measures approximately 6 mm. by 2·50 mm.

Immature insects with a deep marginal indentation between the antennæ.

Habitat.—Massed on the inner surface of the leaves of sugarcane, more especially towards the base of each leaf: Pusa, Bengal. Coll., H. M. Lefroy.

Differs from *D. sacchari* in its more elongate form; in the much longer and proportionately slender legs and antennæ; in the prominent and conspicuous eyes; and in the well-defined spiniferous submarginal patches on each segment.

Dactylopius theæcola (Green).

On roots of tea plant: Darjeeling, Assam. Coll., H. H. Mann.

(See 'Mem. Dep. Ag. Ind.' Entom. Series, Vol. I, No. 5.)

RIPERSIA SACCHARI (Green).

Specimens, said to be associated with widespread damage to rice, are so very near to typical examples of this species that I hesitate to separate them, though the legs are slightly more slender and the tibiæ proportionately longer. On rice plant: Bengal. Coll., H. M. Lefroy.

PHENACOCCUS HIRSUTUS (nov.).

Adult female of normal form. Examples preserved in alcohol, pale greenish yellow. Living insects probably covered with white mealy secretion, but this has been removed by the alcohol. Antennæ comparatively short and stout; 9-jointed, the division between 8th and 9th rather obscure. All the joints with a few scattered fine hairs. A single stout curved bristle near the apex of each of the terminal three joints (Fig. 9). Legs rather large and stout; tibia shorter than femur; tarsus approximately half length of tibia; claw stout, curved, simple; ungual digitules slightly dilated; tarsal digitules fine knobbed hairs, extending beyond tip of claw. Anal tubercles scarcely prominent, each bearing a long stout bristle, several small hairs, and two sharply pointed spines; a pair of similar spines on lateral margin of each of the two preceding segments. Anal ring large, with six stout hairs. Derm set with numerous conspicuous longish, stout hairs. Some large circular spinnerets on the abdominal segments, and many small obscurely trilobed pores. Eyes well defined, with a median cloudy, slightly pigmented area. Length 2 to 2·25 mm. (My examples are possibly not fully grown.)

Habitat.—On the terminal shoots of an undetermined shrub, attended by ants (*Cremastogaster rogenhoferi*), which had constructed shelters round the colonies of insects. Locality not given. Coll., C. Fischer. Occurs also in Tasmania.

Closely allied to *Ph. aceris*, from which it may be distinguished by the relatively shorter and stouter antennæ, by the proportionately longer tarsi, and by the absence of a denticule on the inner edge of the claw.

Phenacoccus iceryoides (nov.).

Adult female secreting a voluminous globose ovisac at the anterior extremity of which the insect may be observed, tilted into a perpendicular position. Margin with a conspicuous fringe of white waxy tassels, longest at the posterior extremity. Abdominal segments well defined by marginal indentations. In many examples a conspicuous dark brown, chitinous sternal plate (transversely elongate) may be observed on the basal segment of the abdomen. Antenna 9-jointed; base short and stout, other joints elongate and slender; 3rd usually longest, but sometimes equalled or even surpassed by 2nd; 9th scarcely longer than 8th. Margin with an almost continuous fringe (interrupted only at junctions of abdominal segments) of short, stout, conical spines, which extend into broad clusters on the abdominal segments. Eyes well defined, prominent. Derm with numerous small circular spinnerets, more crowded towards the margin.

Habitat.—On "Mango:" Calcutta. Coll., I. Burkill. On Boswellia: Tanjore. Coll., C. A. Barber. And on *Capparis horrida:* Surat. Coll., H. M. Lefroy. The insects densely clustered on the smaller stems and branches.

Phenacoccus insolitus (nov.).

Adult female, before oviposition, dark purplish brown, almost naked; two short white processes from anal aperture; margin with fine, straight glassy filaments. During oviposition, the insect deposits first a mass of cottony filaments (upon which it rests), and constructs later an elongate white ovisac. Body (Fig. 10) oblong oval. A complete marginal and three longitudinal series of conspicuous spinous tubercles, the median series absent on abdominal segments, the spines short, stout and sharply pointed. Antenna 9-jointed, the 8th and 9th fused together; 2nd and 9th joints subequal, longest; 4th to 6th subequal and shortest. Eyes well defined. Legs slender; tibia approximately equal to femur and trochanter together; tarsus less than half length of tibia; claw with a small denticule on inner margin at about one-third

from extremity; digitules simple, pointed. Derm with scattered small circular pores, more crowded and conspicuous on margins of abdominal segments. Anal ring with six longish, stout hairs. Length averaging 2 to 2·50 mm. Breadth 1 to 1·50 mm.

Habitat.—On *Sida cordifolia:* Pusa, Bengal. Coll., H. M. Lefroy.

Antonina indica (nov.).

Adult female enclosed in a closely felted white sac; broadly oval or subspherical. Skin smooth, except at posterior extremity where it is slightly rugose and more densely chitinous. Terminal segment not demarked from the previous segment by any marginal incision.

Antenna very rudimentary; sometimes with traces of two or three imperfect joints, but often practically jointless; with a few stout bristles at extremity. Legs wanting. Spiracles large and conspicuous, each with a closely packed group of parastigmatic glands. Derm with numerous conspicuous circular pores which are still more crowded on the marginal and post-abdominal areas. Anal ring (Fig. 11) sunk in a well-marked chitinous pit, with six stout hairs which do not reach the margin of the body. Posterior margin of body with a few stout, spiniform hairs. Length 1·50 to 2 mm. Breadth 1 to 1·50 mm.

Habitat.—At the base of the leaves of "Hariali" grass: Bengal. Coll., H. M. Lefroy. The insects more or less concealed beneath the sheathing bases of the leaves.

Differs from *purpurea* and *australis* in the more evenly rounded posterior extremity, those two species having a prominent pygidiform terminal segment.

Tachardia albizziæ (Green).

On *Croton caudatum:* Darjeeling. (Ind. Mus. Reg. No. 16158.) Coll., Sir Geo. Watt.

TACHARDIA DECORELLA var. THEÆ (Green).

On tea plant: Darjeeling, Assam. Coll., H. H. Mann.

COCCUS INDICUS (nov.).

Coccus cacti var. *ceylonicus*. Green, 'Ind. Mus. Notes,' Vol. IV, No. 1, p. 7.

Adult female, deep purplish brown, densely covered with white mealy wax. Derm covered with stout, cylindrical, truncate spines, each with an expanded sloping base; length of cylinder approximately equal to its breadth; many smaller glandular pores, usually in pairs, forming a figure of eight, sometimes in larger groups, forming rosettes. Antenna with six or seven distinct joints, the smaller number being the result of the confluence of the third and fourth joints. Legs stout and well developed; tarsus markedly longer than tibia; digitules in the form of fine knobbed hairs. Length (of compressed mounted examples) 3 to 4·50 mm. Breadth 2·75 to 3·50 mm.

Male puparium snowy white, cylindrical, open at posterior extremity. Length 1 to 1·25 mm.

Adult male (as observed in Ceylon), purplish crimson, with a pair of very long white caudal filaments. Eyes black, prominent, lateral; ocelli large, black, two on upper and two on undersurface of head. Antenna 10-jointed; each joint with numerous small spicules; last seven joints, each with a pair of long-knobbed hairs. Length about 1 mm.

On *Opuntia dillenii*: Kangra. Coll., I. Burkill. (Reg. No. 15467.) Occurs also at various places on the sea coast of Ceylon.

This species is readily distinguished from *C. cacti* by the presence of the crowded cylindrical spines. Typical *cacti* (the species employed in commerce) has no spines at all, though Cockerell (Amer. Naturalist, Vol. XXVII, Dec. 1893, p. 1045) states that "the skin of all three species (viz. *cacti*, *tomentosus*, and *confusus*) shows numerous truncate processes." Signoret

makes no mention of spines, but says that "the skin is smooth, with groups of spinnerets placed here and there and some scattered hairs." *C. tomentosus* has similar spines, but they are proportionately longer and much numerous. I have been unable to compare the present species with *C. confusus*, but that species is said by Cockerell to have the spines much more slender than in *tomentosus*, while *indicus* has the spines very short and stout.

Lecanium capreæ (Linn.).

On Almond tree: Baluchistan. Coll., E. P. Stebbing.

The insects are reported to "kill off the branches and, eventually, the trees."

Lecanium expansum (Green).

On *Ficus retusa*: Mysore. Coll., H. M. Lefroy.

Lecanium formicarii (Green).

On undetermined plant: Mysore. Coll., H. M. Lefroy.

Lecanium gymnospori (nov.).

Adult female (dried examples), deep ochreous, sometimes mottled with reddish brown. Eyes black. Elongate oval; shrivelled and wrinkled when dry. Traces of an irregular median carina. Antenna (Fig. 13) 8-jointed, third and fourth rather closely fused together; 3rd, 5th and 8th longest and subequal; formula (exclusive of 1st), (3, 5, 8), (2, 4), (6, 7). Legs slender; tarsus much shorter than tibia; ungual digitules only narrowly dilated. Valves of anal operculum with apical angle acute; outer edge slightly longer than base; lateral angle rectangular. Marginal hairs fine, curved; some simple, others slightly frayed at extremity. Stigmatic clefts, with one long, stout spine and two or three much shorter ones. Derm cells distinct but small, round or oval. Length 3·50 to 4·50 mm. Breadth 3 mm.

Differs from *hesperidum* in the number of proportion of the antennal joints, and in the larger size of the insect. Distinguished from *punctuliferum* by the antennal formula and the narrower anal operculum.

Habitat.—On leaves and small branches of *Gymnosporia montana*. Coll., H. M. Lefroy.

Lecanium hesperidum (L.).

In nests of *Œcophylla*, on *Dalbergia latifolia* and on undetermined plant: Pusa, Bengal. Coll., H. M. Lefroy.

Lecanium longulum (Dougl.).

On *Vitis* sp.: Sonari, Assam. Coll., H. M. Lefroy.

Lecanium mangiferæ (Green).

On "Mango:" Pusa, Bengal. Coll., H. M. Lefroy.

Lecanium marsupiale (Green).

On *Piper nigrum:* Wynaad. Coll., C. A. Barber.

Lecanium montanum (nov.).

Adult female (Fig. 14) globular. Polished; dorsum covered with minute, rounded granulations, and with numerous irregular depressed spots. Dark castaneous. Margin outturned, but concealed by the swollen sides of the dorsum. Derm cells inconspicuous, except around anal operculum and on marginal area where they produce a reticulate pattern. Antenna (Fig. 15) 6-jointed, third as long as or longer than terminal three together, and somewhat swollen. Legs small and slender; tibia and tarsus subequal; ungual digitules scarcely dilated. Margin with small but rather stout, bluntly pointed spiniform hairs. Stigmatic areas ill defined; without specialized spines. Valves of anal operculum triangular;

together subquadrate; base equal to outer edge. Operculum situate towards posterior extremity. Anal cleft distinct with its edges upturned and contiguous, forming a more or less distinct carina. Length 2·50 to 3·50 mm. Breadth 2 to 3 mm.

Male not observed in any stage.

Insects crowded on twigs of undetermined shrub: Janusai, Himalayas (7,000 ft.). Coll., C. Fischer.

Somewhat resembling *Cryptes* in form, but differing in position of anal operculum and in the presence of a distinct anal cleft.

LECANIUM NIGRUM (Nietner).

On *Gossypium*: Pusa, Bengal. On *Capparis sepiaria*: Calcutta. Coll., H. M. Lefroy.

LECANIUM PERSICÆ (Fab.).

On *Morus indica*: Jhelum, Punjab. Coll., I. H. Burkill. (Ind. Mus. Reg. No. 16393.)

The present examples correspond with Signoret's description in every particular. Leonardi (Ins. Nox., Vol. IV, p. 481) records the species on *Morus alba* and *Morus nigra*, in Italy. He, however, describes the adult female as having 7-jointed antennæ. Signoret puts the number of antennal joints at 8, and my specimens agree in this particular.

PULVINARIA BURKILLI (nov.).

Adult female, with a marginal fringe of longish, stout, truncate spines (Fig. 16); as in *P. maxima*, their extremities emarginate. Antenna slender; 8-jointed; third very long, slightly longer than fourth and fifth together; terminal three very short. Legs rather stout; tarsus scarcely half length of tibia; claw short and stout, strongly curved; ungual digitules broadly dilated. Stigmatic cleft with a group of four or five longer pointed spines. Some short, stout, pointed spines scattered over the venter. Valves of anal-

operculum elongate; lateral angle obtuse; some stout spines near apex. Derm without conspicuous cells. Length 4 mm. Breadth 2 mm.

Ovisac (as judged from the scars on the leaf) very long and narrow, about 12 mm. long.

Habitat.—On leaves of *Croton tiglium*: Siugaing (near Calcutta). Coll., I. Burkill.

Differs from *P. maxima* in its much smaller size, and in the absence of conspicuous derm cells.

Described from material in very poor condition, from which neither the natural form of the insect or its ovisac could be determined with accuracy.

Pulvinaria psidii (Mask.).

On "Guava" *(Psidium)*, *Eugenia*, and tea plant: Nilgiris. Coll., H. L. Andrewes. On *Ficus* sp.: Mysore. Coll., H. M. Lefroy.

Ceroplastodes Cajani (Mask.).

On *Ocimum sanctum*: Calcutta. Coll., H. W. Peal. On *Coleus*: Surat. Coll., H. M. Lefroy.

Ceroplastodes chiton (Green nomen nud.).

On *Cajanus indicus*: Darjeeling. Coll., H. H. Mann.

Though occurring on the original food-plant of *C. cajani*, this species—which is found also in Ceylon—is amply distinct from Maskell's type, both in the characters of the antennæ and in the structure of the female test.

Ceroplastes rubens (Mask.).

Wrongly determined as *C. myricæ*. (Ind. Mus. Notes, Vol. V, No. 1, p. 8.)

Ceroplastes vinsonii (Sign.).

This species was included in my preliminary catalogue of Indian Coccidæ (Ind. Mus. Notes, Vol. V, No. 1, p. 12), but I cannot find any authority for its inclusion. It appears to have been recorded only from Mauritius and Reunion Island.

Aspidiotus destructor (Sign.).

On Mango leaves: Nariad, Kaira District. Coll., I. H. Burkill.

Aspidiotus ficus (Ashm.).

On *Phoenix* sp: Calcutta. Coll., H. M. Lefroy. On *Areca catechu*: Bombay. Coll., I. H. Burkill. Previously determined by Maskell from examples collected on orange leaves, Poona, by Col. M. Woodrow.

Aspidiotus lataniæ (Sign.).

On Peach: Coonoor. Coll., H. L. Andrewes. On *Phœnix* sp.: Calcutta. Coll., H. M. Lefroy.

Aspidiotus orientalis (Newstead).

On *Dalbergia*. Coll., H. H. Mann. On *Tamarindus*. Coll., H. M. Lefroy.

On examining fresh material of this species, a character is observed that is usually obscured in dried specimens. The two squamæ immediately exterior to the outer lobes of the pygidium are produced into pinnæ, as in *Chrysomphalus dictyospermi* var *pinnulifera*.

Aspidiotus (Chrysomphalus) triglandulosus (nov.).

Female puparium capsulate, as in *capsulatus* and *cistuloides*. Moderately convex; subcircular, the anterior extremity slightly narrowed and bluntly pointed; the posterior margin raised by the thickened ventral scale. Dark blackish brown, dusted above

with a grayish bloom. Larval pellicle brownish ochreous, eccentric, placed close to anterior extremity. Nymphal pellicle concealed. Greater diameter 1·50 mm.

Male puparium oblong oval; flattish, the median anterior area moderately convex, where it supports the pellicle. Dark blackish brown. Length 1 mm. Breadth 0·60 mm.

Adult subcircular, the pygidium scarcely projecting. A conspicuous transverse furrow behind the cephalo-thoracic segment, where the margin is slightly indented. Pygidium (Fig. 17), with 6 small lobes; the median pair rounded, the other two pairs with slightly excised apical margins; first two lobes on each side close together, the third separated by about twice its own width. Margin beyond the lobes strongly cristate and irregularly serrate. Paraphyses moderately developed, 4 on each side, one in each interval between the lobes, one at commencement of cristate area, and one at the third indentation. Squamæ rather narrow; obscurely pectinate. Anal aperture elongate, narrow (almost linear), distant from margin by little more than its own length. A dense group of parastigmatic glands in front of anterior spiracles. Dorsal pores minute and inconspicuous. Circumgenital glands in three groups, with few orifices; median 4 to 6, laterals 3 to 6; average number in each group 4. Length 1·0 to 1·25 mm.

Habitat.—On undersurface of leaves of undetermined tree: Mahableshwar, Bombay. Coll., H. M. Lefroy.

Closely allied to *cistuloides*, but differing in the more evenly rounded margin without any marked separation of the pygidial area. In *cistuloides* the posterior margin of female pygidium is bluntly pointed, and the pellicles are less eccentric.

MYTILASPIS PIPERIS (nov.).

Female puparium brownish red, exuviæ bright reddish. Intermediate in form between *citricola* and *gloveri;* narrower and straighter than the former, but broader and not so parallel sided as the latter. Length 2·25 to 3 mm. Breadth 0·70 mm.

Male puparium similar but smaller. Length 1·25 mm.

Adult resembles *citricola* in the presence of crowded series of small dorsal pores on the pygidium (Fig. 18), but differs in the smaller median lobes which are also more widely separate, and by a small but prominent median marginal point between the squamæ of the median interlobular space. Differs from *gloveri* and *cocculi* in the character of the dorsal pores (*gloveri* having fewer and larger pores, while in *cocculi* there appear to be no pores). Frontal fold moderately developed. Length 0·80 to 1·25 mm.

Habitat.—On the young stems of *Piper nigrum :* Madras. Coll., C. A. Barber.

It is remarkable that this is the first and only species of *Mytilaspis* that has been recorded from the continent of India.

Aonidia distinctissima (Newst.).

Originally described under the name of *Parlatoria distinctissimus*, from Baluchistan. (Accidentally omitted from previous lists.)

Parlatoria proteus (Curtis) var Mytilaspiformis (Green).

On *Cycas revoluta* and *Kentia :* Bombay. Coll., H. M. Lefroy.

Diaspis Barberi (nov.).

Female puparium opaque white; subcircular, sometimes bluntly pointed at posterior extremity; moderately convex above. Pellicles eccentric, placed towards anterior margin : larval pellicle reddish, exposed; nymphal pellicle castaneous or ochreous, very thinly coated with secretion. Greater diameter 2 mm.

Male puparium unknown.

Adult female widely turbinate, broadest across thoracic segments. Margins of abdominal segments slightly roundly produced. Anterior spiracles with a large group of parastigmatic glands. Median lobes of pygidium (Fig. 19), divergent, prominent, broadly

flabelliform, constricted at base, the rounded outer edge slightly and irregularly incised. First lateral lobes duplex; the inner lobule prominent, very slightly dilated towards extremity which is roundly truncate; outer lobule very small, conical. Other lobes obsolete. Squamæ spiniform, longest at base of pygidium. Groups of short, stout squamæ on the margins of the last three abdominal segments. Anal aperture approximately central. Circumgenital glands in five groups; median group 6 to 9; upper laterals 18 to 23; lower laterals 19 to 23; average of six examples, median 8, upper laterals 20, lower laterals 22. Dorsal oval pores numerous, large and conspicuous. Length 0·75 to 0·85 mm.

Pygidial lobes of nymphal pellicle similar to those of adult female.

Habitat.—Crowded on the branches of *Loranthus* sp.: Tanjore. Coll., C. A. Barber.

Differs from *pentagona* in the form of the median lobes of the pygidium, which are conspicuously constricted at the base and broadly rounded at the extremity.

Diaspis echinocacti (Bouche).

On *Opuntia:* Poona. Coll., H. M. Lefroy.

Previously determined by Maskell from specimens collected by Sir Geo. Watt, on prickly pear from S. India. (See Ind. Mus. Notes, Vol. IV, p. 211.)

Chionaspis biclavis (Comst.).

On tea plant: Nilgiris. Coll., H. L. Andrewes.

Not previously recorded from the Indian continent.

Chionaspis dilatata (Green).

Female puparia narrower and more oblong than in the Ceylon form.

On a species of palm; Calcutta. Coll., H. W. Peal.

CHIONASPIS GRAMINIS var. DIVERGENS (Green).

On *Andropogon:* Bharwain, Hoshiarpur. Coll., I. H. Burkill.

CHIONASPIS MANNI (Green).

On branches of tea plant: Assam, Darjeeling. Coll., H. H. Mann. On *Ficus* sp.: Kangra Valley. And on *Solanum melongena:* Calcutta. Coll., I. H. Burkill.

CHIONASPIS PRUNICOLA var. THEÆ (Mask.).

This is probably identical with *Ch. manni*, mihi, as noted in Ind. Mus. Notes, Vol. V, p. 12 (footnote). It is almost certainly distinct from Maskell's type of *prunicola* which has been proved to be a synonym of *Diaspis pentagona*.

CHIONASPIS VITIS (Green).

On "Mango:" Pusa, Bengal. Coll., H. M. Lefroy. On *Elæagnus:* Coonoor. Coll., H. L. Andrewes.

HEMICHIONASPIS FICI (nov.).

Female puparium white, thin and semi-transparent. Of broad and irregular form.

Male puparium opaque white, sharply tricarinate. Horizontal. Length 1 mm.

Adult female of normal form, broadest across median abdominal segments, the margins of which are produced into broadly rounded lobes. Anterior spiracles with a small group of parastigmatic glands. Pygidium broad, bluntly pointed. Median lobes (Fig. 20), large and prominent, closely approximated, minutely serrate or crenulate on free edge, together forming a semi-circle. First lateral lobes small, duplex, narrow and inconspicuous, scarcely projecting beyond margin. Other lobes obsolete. Squamæ stout and moderately long. Dorsal oval pores few, but large and conspicuous. Circumgenital glands in five groups: number of orifices

very irregular. Described from three examples in which the numbers were as follows :—

8	10	1
19 — 21,	18 — 23,	13 — 15
17 — 18,	25 — 23,	19 — 17

Length 0·75. Breadth 0·50 mm.

Habitat.—On stems of *Ficus glomerata*: Pusa, Bengal. Coll., H. M. Lefroy.

The material consisted of a mass of male puparia beneath which were concealed a very few females.

Resembles *rhododendri* and *scrobicularum* in the semi-circular outline of the united median lobes, but differs in the proportionate size of these lobes which are relatively and actually smaller in the present species.

Hemichionaspis minima (nov.).

Female puparium whitish, almost colourless, more or less translucent, often obscured by an admixture of the tomentum of the leaf. Moderately elongate, broadest across the middle. Larval pellicle pale yellow ; nymphal pellicle ochreous or brownish ochreous. Length averaging 1·50 mm. Greatest breadth 0·75 mm.

Male puparium white opaque, obscurely tricarinate. Pellicle very pale yellow. More or less erect on the leaf, attached only at the anterior extremity. Length 0·80 mm.

Adult female of normal form, narrowed in front, broadest across the base of the pygidium. Margins of abdominal segments scarcely produced. Median pygidial lobes (Fig. 21) closely approximated, scarcely projecting beyond margin, widest towards extremity which is strongly denticulate. First lateral lobes narrow, duplex, the lobules equal in breadth. Other lobes obsolete. Anal aperture approximately central, rather nearer the base of pygidium. Dorsal oval pores few. Circumgenital glands in five groups; median 7 to 12 (average 7); upper laterals 10 to 13 (average 12) ; lower laterals 10 to 12 (average 10). Length 0·50 mm.

Habitat.—On undersurface of leaves of "Banian" tree (*Ficus* sp.) : Pusa, Bengal. Coll., H. M. Lefroy.

This species differs from any other *Hemichionaspis* known to me in its minute size. The puparia at first sight look very like those of *Chionaspis minuta*.

Hemichionaspis minor (Mask.).

On *Crotalaria hirsuta*: Calcutta. Coll., D. Prain. (See Ind. Mus. Notes, Vol. V, p. 127).

Fiorinia theæ (Green).

On *Citrus*: Calcutta. Coll., H. W. Peal.

CATALOGUE OF INDIAN COCCIDÆ.

MONOPHLEBINÆ.

1.	*Monophlebus atripennis* ...	Burm. 'Handb. Ent.,' ii, p. 80 (1835). Green, 'Ind. Mus. Notes,' vol. v, p. 13 (1900).
2.	,, *burmeisteri* ...	Westw., 'Arc. Ent.,' i, p. 22 (1841). Green, 'Ind. Mus. Notes,' vol. v, p. 13 (1900).
3.	,, *leachii* ...	Westw., 'Arc. Ent.,' i, p. 22 (1841). Green, 'Ind. Mus. Notes,' vol. v, p. 13 (1900).
4.	,, *saundersi* ...	Westw., 'Arc. Ent.,' i, p. 22 (1841). Green, 'Ind. Mus. Notes,' vol. v, p. 13 (1900).
5.	,, *stebbingi* ...	Green, 'Ind. Mus. Notes,' vol. v, p. 100 (1903).
	,, *stebbingi octocaudata.*	Green, nov.
6.	,, *dalbergiæ* ...	Green, 'Ind. Mus. Notes,' vol. v, p. 101 (1903).
7.	,, *tamarindus* ...	Green, nov.
8.	*Icerya ægyptiaca* ...	Dougl., 'Ent. Mo. Mag.,' xxvi, p. 79 (1890). Newst., 'Ind. Mus. Notes,' iii, No. 5, p. 27. Green, 'Ind. Mus. Notes,' v, p. 13 (1900).
9.	,, *seychellarum* ...	Westw., 'Gard. Chron.,' p. 830 (1855). Green, 'Ind. Mus. Notes,' iv, No. 1, p. 6 (1896).
10.	,, *minor* ...	Green, nov.
11.	,, *pilosa* ...	Green, 'Ind. Mus. Notes,' iv, No. 1, p. 7 (1896).

12. *Walkeriana cinerea* ... Green, nom. nud.
13. „ *polei* ... Green, 'Ind. Mus. Notes,' iv, No. 1, p. 6 (1896).
14. *Perissopneumon ferox* ... Newst., 'Ent. Mo. Mag.,' xxxvi, p. 250 (1900).

MARGARODINÆ.

15. *Margarodes formicarum* ... Guild., 'Tr. Linn. Soc., Lond.,' p. 115 (1828).
    Atkinson, 'Journ. As. Soc., Bengal,' lv, pt. 2, No. 3.

ASTEROLECANIINÆ.

16. *Asterolecanium grande* ... Newst., 'Ent. Mo. Mag.,' xxx, p. 182 (1894).
17. „ *miliaris* boisd., *var. robusta.* Green, nov.
18. *Cerococcus ficoides* ... Green, 'Ent. Mo. Mag.,' xxxv, p. 225 (1899).
    Green, 'Ind. Mus. Notes,' v, p. 102 (1903).
19. „ *hibisci* ... Green, nov.

ERIOCOCCINÆ.

20. *Eriococcus paradoxus indicus* ... Mask., 'N. Z. Trans.,' xxix, p. 318 (1897).
    Barlow, 'Ind. Mus. Notes,' iv, p. 210.
21. *Lefroyia castaneæ* ... Green, nov.

DACTYLOPIINÆ.

22. *Dactylopius bromeliæ* ... Bouche, 'Schadl. Gart. Ins.,' p. 49 (1833).
    Cotes, 'Ind. Mus. Notes,' iii, No. 5, p. 51 (1894).
23. „ *citri* ... Risso, 'Ess. Hist. Nat. d. Oranges,' (1813).
    Green, 'Ind. Mus. Notes,' v, p. 100 (1903).
24. „ *formiceticola* ... Newst., 'Ent. Mo. Mag.,' xxxvii, p. 86 (1901).
25. „ *nipæ* ... Mask., 'N. Z. Trans.,' p. 232 (1892).

26.	*Dactylopius sacchari*	...	Ckll., 'Jn. Trin. Nat. Club,' ii, p. 195 (1895).
			Green, 'Ind. Mus. Notes,' v, No. 3, p. 102 (1903).
27.	,, *saccharifolii*	...	Green, nov.
28.	,, *theaecola*	...	Green, 'Ent. Mem. Dep. Ag. Ind.,' i, No. 5, p. 347 (1907).
29.	,, *viridis*	...	Newst., 'Ind. Mus. Notes,' iii, No. 6, p. 25 (1894).
30.	,, *virgatus*	...	Ckll., 'The Entomologist,' xxvi, p. 178 (1893).
	ceriferus	...	Newst., 'Ind. Mus. Notes,' iii, No. 5, p. 25 (1894).
	talini	...	Green, 'Ind. Mus. Notes,' iv, No. 1, p. 7 (1896).
31.	*Ripersia sacchari*	...	Green, 'Ind. Mus. Notes,' v, p. 37 (1900).
32.	*Phenacoccus hirsutus*	...	Green, nov.
33.	,, *iceryoides*	...	Ditto.
34.	,, *insolitus*	...	Ditto.
35.	*Antonina indica*	...	Ditto.

TACHARDIINÆ.

36.	*Tachardia albizziæ*	...	Green, nom. nud.
37.	,, *decorella*	...	Mask., 'N. Z. Trans.', xxv, p. 247 (1892).
			Barlow, 'Ind. Mus. Notes,' iv, p. 58 (1896).
	,, *decorella theæ*	...	Green, 'Ent. Mem. Dep. Ag Ind.,' i, No. 5, p. 348 (1907).
38.	,, *fici* ...	...	Green, 'Ind. Mus. Notes,' v, p. 97 (1903).
39.	,, *lacca* ...	...	Kerr, 'Philos. Trans.,' lxxi, p. 374 (1782).
			Green, 'Ind. Mus. Notes,' v, p. 12 (1900).

COCCINÆ.

(Cochineal insects).

40.	*Coccus indicus* ...	...	Green, nov.

LECANIINÆ.

41.	*Lecanium capreæ*	...	Linn., 'Syst. Nat.,' ed. xii, i, p. 741 (1766).
42.	,, *expansum*	...	Green, 'Ind. Mus. Notes,' iv, p. 9 (1896).
43.	,, *formicarii*	...	Green, 'Ind. Mus. Notes,' iv, p. 10 (1896).

44.	*Lecanium gymnospori* ..	Green, nov.
45.	„ *hemisphæricum* ...	Targ. 'Stud. sul Cocc.' (1867).
		Cotes, 'Ind. Mus. Notes,' ii, p. 163, and iii, No. 4, p. 41.
		Green, 'Ind. Mus. Notes,' v, p. 7 (1900).
46.	„ *hesperidum* ...	Linn., 'Syst. Nat.', ed. x, 1, p. 455 (1758).
47.	„ *imbricans* ...	Green, 'Ind. Mus. Notes,' v, p. 94 (1903).
48.	„ *longulum* ...	Dougl., 'Ent. Mo. Mag.,' xxiv, p. 97 (1887).
49.	„ *mangiferæ* ...	Green, 'Ent. Mo. Mag.,' xxv, p. 249 (1889).
50.	„ *marsupiale* ...	Green, 'Cocc. Ceyl.,' iii, p. 212 (1904).
51.	„ *montanum* ...	Green, nov.
52.	„ *nigrum* ...	Nietn., 'Enemies of Coffee tree,' p. 9 (1861).
		Atkinson, 'Journ. As. Soc. Beng.,' lv, p. 284.
		Cotes, 'Ind. Mus. Notes,' ii, p. 168.
53.	„ *persicæ* ...	Geoff., 'Hist. Abr. Ins.,' i, p. 506 (1762).
54.	„ *viride*	Green, 'Ent. Mo. Mag.,' xxv, p. 248 (1889).
55.	„ *watti*	Green, 'Ind. Mus. Notes,' v, p. 6 (1900).
56.	*Pulvinaria burkilli* ...	Green, nov.
57.	„ *floccifera* ...	Westw., 'Gard. Chron.,' p. 308 (1870).
		Green, 'Ind. Mus. Notes,' v, p. 7 (1900).
58.	*Pulvinaria obscura* ...	Newst., 'Ind. Mus. Notes,' iii, No. 5, p. 23 (1894).
		Green, 'Ind. Mus. Notes,' v, p. 12 (1900).
59.	„ *psidii* ...	Mask., 'N. Z. Trans.,' xxv, p. 223 (1892).
60.	*Ceroplastodes cajani* ...	Mask., 'Ind. Mus. Notes,' ii, p. 61 (1891).
		Green, 'Ind. Mus. Notes,' v, p. 12 (1900).
61.	„ *chiton* ...	Green, nom. nud.
62.	*Ceroplastes ceriferus* ...	Anderson, 'Mon. Cocc. Cerif.,' (1791).
		Green, 'Ind. Mus. Notes,' v, p. 8 (1900).
63.	„ *floridensis* ...	Comst., 'Rep., U. S. Dep. Ag., 1880,' p. 331 (1881).
		Green, 'Ind. Mus. Notes,' v, p. 8 (1900).
64.	„ *rubens* ...	Mask., 'N. Z. Trans.,' xxv, p. 214 (1892).
		Green, 'Ind. Mus. Notes,' v, p. 8, (wrongly attributed to *myricæ*, Linn.).
		Green, 'Ent. Mem. Dep. Ag. Ind.,' i, No. 5, p. 340 (1907).

65. *Ceronema japonica* ... Mask., 'Ent. Mo. Mag.,' xxxiii, p. 243 (1897).
Green, 'Ind. Mus. Notes,' v, p. 11 (1900).
66. *Eriochiton theæ* .. ... Green, 'Ind. Mus. Notes,' v, p. 10 (1900).
67. *Pseudopulvinaria sikkimensis* Atkinson, 'Journ. As. Soc. Beng.,' pt. ii, No. 1, p. 58 (1889).
Atkinson, 'Ind. Mus. Notes,' i, p. 6.
68. *Inglisia bivalvata* ... Green, 'Ind. Mus. Notes,' v, p. 95 (1903).
69. *Aclerda japonica* ... .. Newst., 'Ent. Mo. Mag.,' xxxvii, p. 84 (1901).
Green, 'Ind. Mus. Notes,' v, p. 95 (1903).

DIASPIDINÆ.

70. *Aspidiotus artocarpi* ... Green, 'Ent. Mo. Mag.,' xxxii, p. 200 (1896).
71. ,, *aurantii* .. Mask. 'N. Z. Trans.,' xi, p. 199 (1878).
Green, 'Ind. Mus, Notes,' v, p. 2 (1900).
72. ,, *camelliæ* .. Sign., 'Ann. Soc. Ent. Fr.,' (4), ix, p. 117 (1869).
Green, 'Ind. Mus. Notes,' v, p. 2 (1900).
73. ,, *destructor* .. Sign., 'Ann. Soc. Ent. Fr.,' (4), ix, p. 120 (1869).
Cotes, 'Ind. Mus. Notes,' ii, p. 168.
Cotes, 'Ind. Mus. Notes,' iii, No. 1, p. 66.
74. ,, *dictyospermi pinnulifera.* Mask., 'N. Z. Trans.,' xxiii, p. 4 (1890).
Green, 'Ind. Mus Notes,' v, p. 2 (wrongly attributed to *arecæ*, Newst.).
75. ,, *ficus* ... ... Ashm., 'Ann. Ent.,' iii, p. 267 (1880).
76. ,, *glomeratus* .. Green, 'Ind. Mus. Notes,' v, p. 93 (1903).
77. ,, *lataniæ* ... Sign., 'Ann. Soc. Ent. Fr.,' (4), ix, p. 124 (1869).
Green, 'Ind. Mus. Notes, v, p. 102 (1903).
78. ,, *moorei* ... Green, 'Ent. Mo. Mag.,' xxxii, p. 199 (1896).
Green, 'Ind. Mus. Notes, v, p. 2 (1900).
79. ,, *orientalis* ... Newst., 'Ind. Mus. Notes,' iii, No. 5, p. 26 (1894).
Green, 'Ind. Mus. Notes,' v, p. 3 (1900).
80. ,, *theæ* ... ... Mask., 'Ind. Mus. Notes,' ii, p. 59 (1891).
Green, 'Ind. Mus. Notes,' v, p. 3 (1900).
81. ,, *triglandulosus* ... Green, nov.

82.	*Aspidiotus trilobitiformis*	...	Green, 'Ind. Mus. Notes,' iv, p. a. (1896). Green, 'Cocc. Ceyl.,' pt. i, p. 41.
83.	*Mytilaspis piperis*	...	Green, nov.
84.	*Parlatoria proteus*	...	Curtis, 'Gard. Chron.,' p. 676 (1843).
85.	,, *ziziphus*	...	Lucas, 'Bull. Soc. Ent. Fr.,' (i), i, p. xxviii, (1853). Green, 'Ind. Mus. Notes,' v, p. 102.
86.	*Aonidia distinctissima*	..	Newst., 'Ent. Mo. Mag.,' xxxii, p. 133 (1896).
87.	*Diaspis barberi* ...	...	Green, nov.
88.	,, *echinocacti*	...	Bouche, 'Schadl. Gart Inst.,' p. 53 (1833).
89.	,, *pentagona theæ*	...	Mask., 'N. Z. Trans.,' xxviii, p. 389 (1896). Green, 'Ind. Mus. Notes,' v, p. 12.
	(*Ch. manni*	...	Green, see below).
90.	*Chionaspis biclavis*	...	Comst., '2nd. Rep., Dep. Ent., Corn. Univ., p. 98 (1883). Green, 'Ind. Mus. Notes,' iv, p. 2 (1896). Green, 'Cocc. Ceyl.,' pt. ii, p. 152 (1899).
91.	,, *decurvata*	...	Green, 'Ind. Mus. Notes,' v, p. 63 (1903)
92.	,, *dilatata*	...	Green, 'Cocc. Ceyl.,' pt. ii, p. 148 (1899).
93.	,, *graminis divergens*		Green, 'Cocc. Ceyl.,' pt. ii, p. 123 (1899).
94.	,, *manni*	...	Green, 'Mem. Ent., Dep. Ag., Ind.,' i, no. 5, p. 344 (1907).
95.	,, *vitis* ...	...	Green, 'Ind. Mus. Notes,' iv, p. 3 (1896). Green, 'Cocc. Ceyl.,' pt. ii, p. 140. Green, 'Ind. Mus. Notes,' v, p. 5.
96.	*Hemichionaspis aspidistræ*	...	Sign., Ann. Soc. Ent. Fr.,' (4), ix, p. 443 (1869). Cotes, 'Ind. Mus. Notes,' ii, No. 1, p. 17. Cotes, 'Ind. Mus. Notes,' iii, No. 5, p. 52.
97.	,, *fici*	...	Green, nov.
98.	,, *minima*	...	Green, nov.
99.	,, *minor*	...	Mask., 'N. Z. Trans.,' xvii, p. 33 (1884).
100.	,, *separata*	..	Green, 'Ind. Mus. Notes,' v, p. 5 (1900).
101.	,, *theæ*	...	Mask., 'Ind. Mus. Notes,' ii, no. 1, p. 60 (1891). Cotes, 'Ind. Mus. Notes,' iii, No. 4, p. 39. Green, 'Cocc. Ceyl.,' pt. ii, p. 113.
102.	*Fiorinia theæ* ...	...	Green, 'Ind. Mus. Notes,' v, p. 3.

Explanation of Figures.

Fig.		
1.	*Icerya minor* ...	... Ventral scars, × 70.
2.	*Cerococcus hibisci*...	... Test of early adult female, dorsal view, 12.
3.	" " ...	... Test of mature female, dorsal view, × 12.
4.	" " ...	. Adult female, optical section, × 50.
5.	*Lefroyia castaneæ*...	... Test of adult female, × 5.
6.	" " ...	... Adult female, optical section, × 9.
7.	" " ...	... Anal aperture, dorsal view, × 250.
8.	" " ...	... Dermal pores, from dorsum, × 450.
9.	*Phenacoccus hirsutus*	.. Part of anterior extremity, showing antenna, leg, eye, and dermal hairs, × 250.
10.	" *insolitus*	... Adult female, optical section, × 50.
11.	*Antonina indica* ...	... Adult, female abdominal extremity, from below, × 250.
12.	*Coccus indicus* ...	... Dorsal spines and glands, × 450.
13.	*Lecanium gymnosporiæ*	... Antenna of adult female, 250.
14.	*Lecanium montanum*	... Adult female, side view, 10.
15.	" "	... Antenna of adult female, 250.
16.	*Pulvinaria burkilli*	... Marginal fringe and stigmatic cleft, 250.
17.	*Aspidiotus triglandulosus*	... Pygidium of adult female, 250.
18.	*Mytilaspis piperis*	... Pygidium of adult female, 250.
19.	*Diaspis barberi* ...	... Pygidium of adult female, 250.
20.	*Hemichionaspis fici*	... Extremity of pygidium, 450.
21.	*Hemichionaspis minima*	... Extremity of pygidiun, 450.

PLATE II.

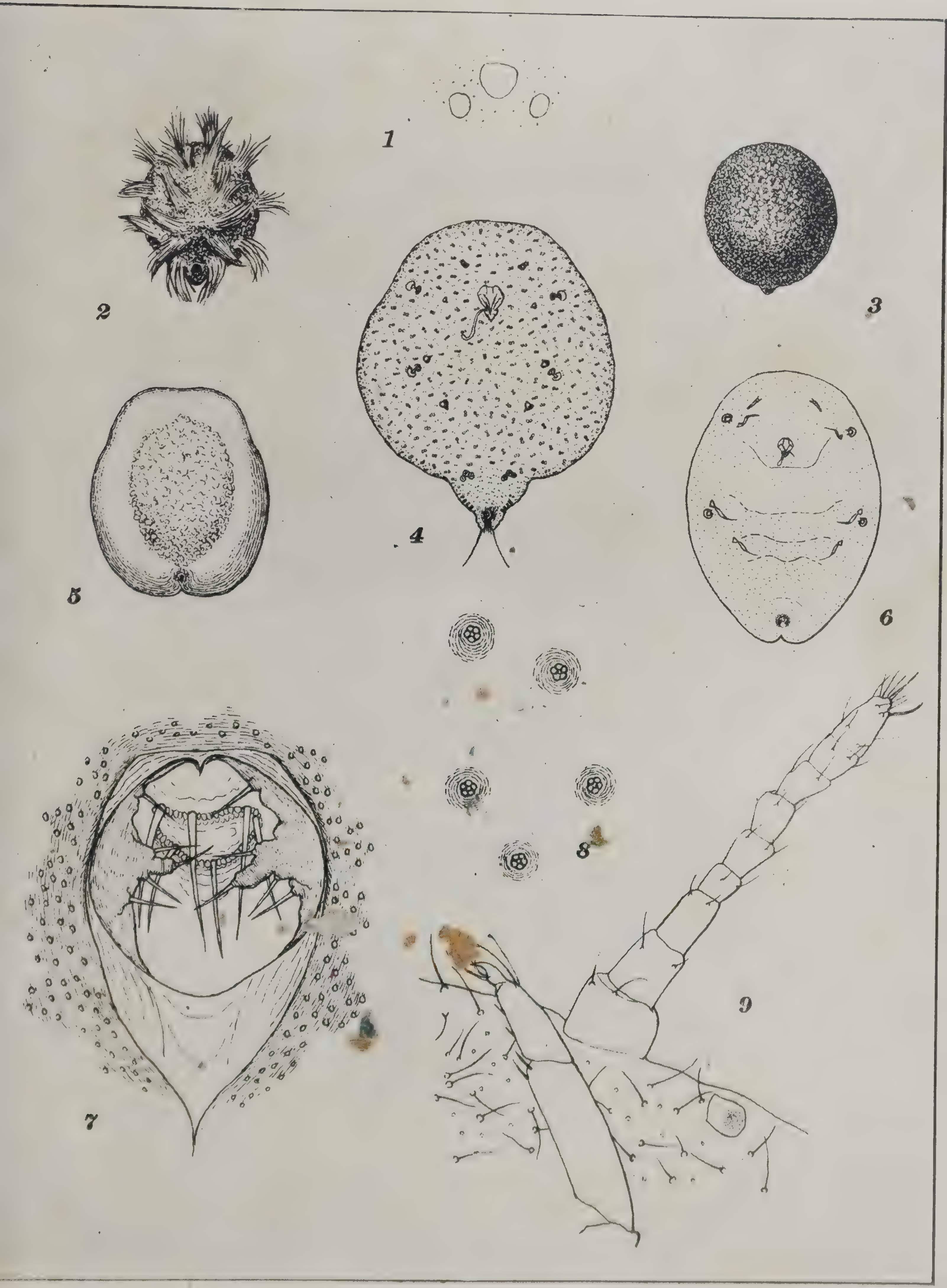


PLATE III.

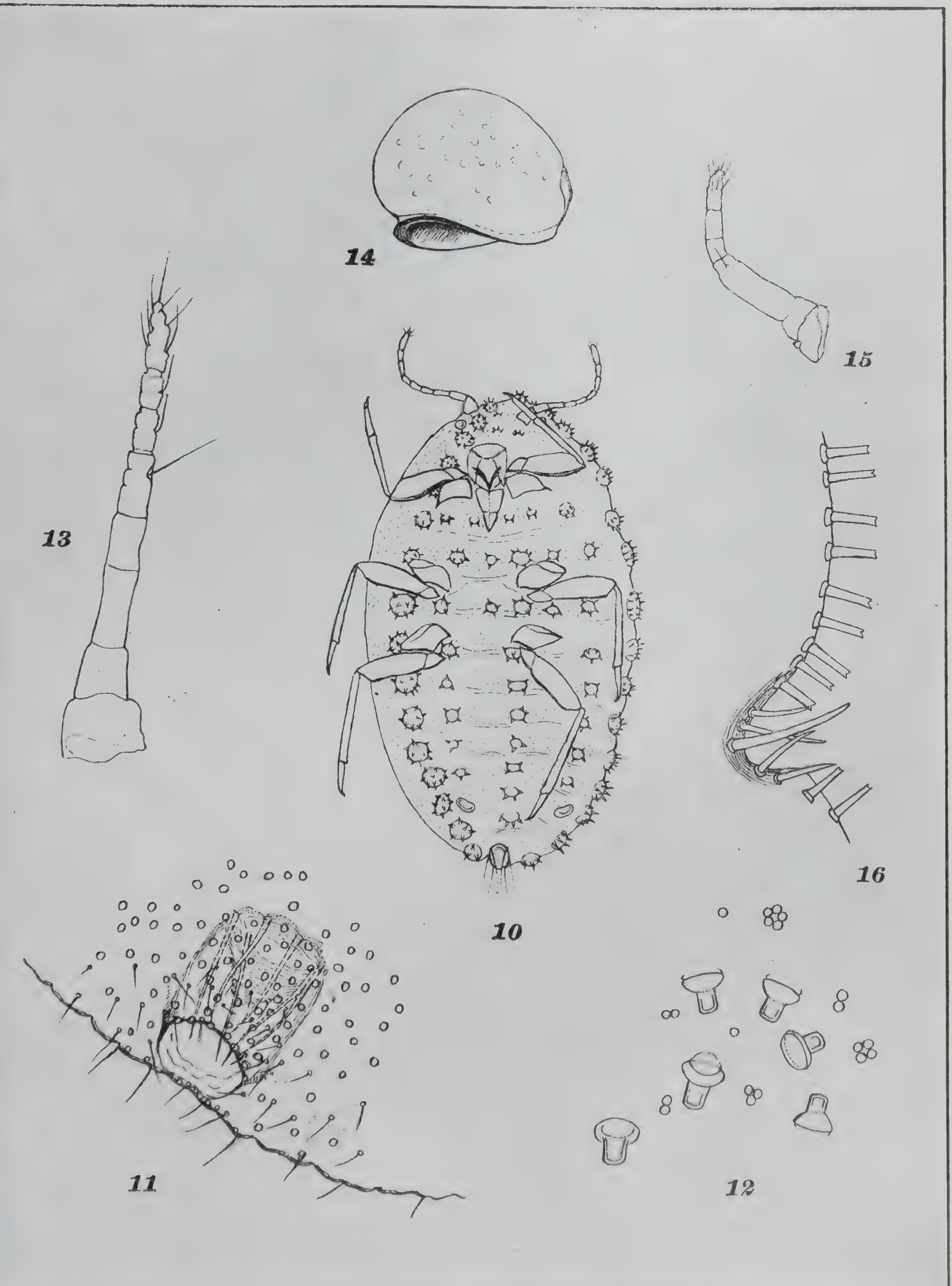


PLATE IV.

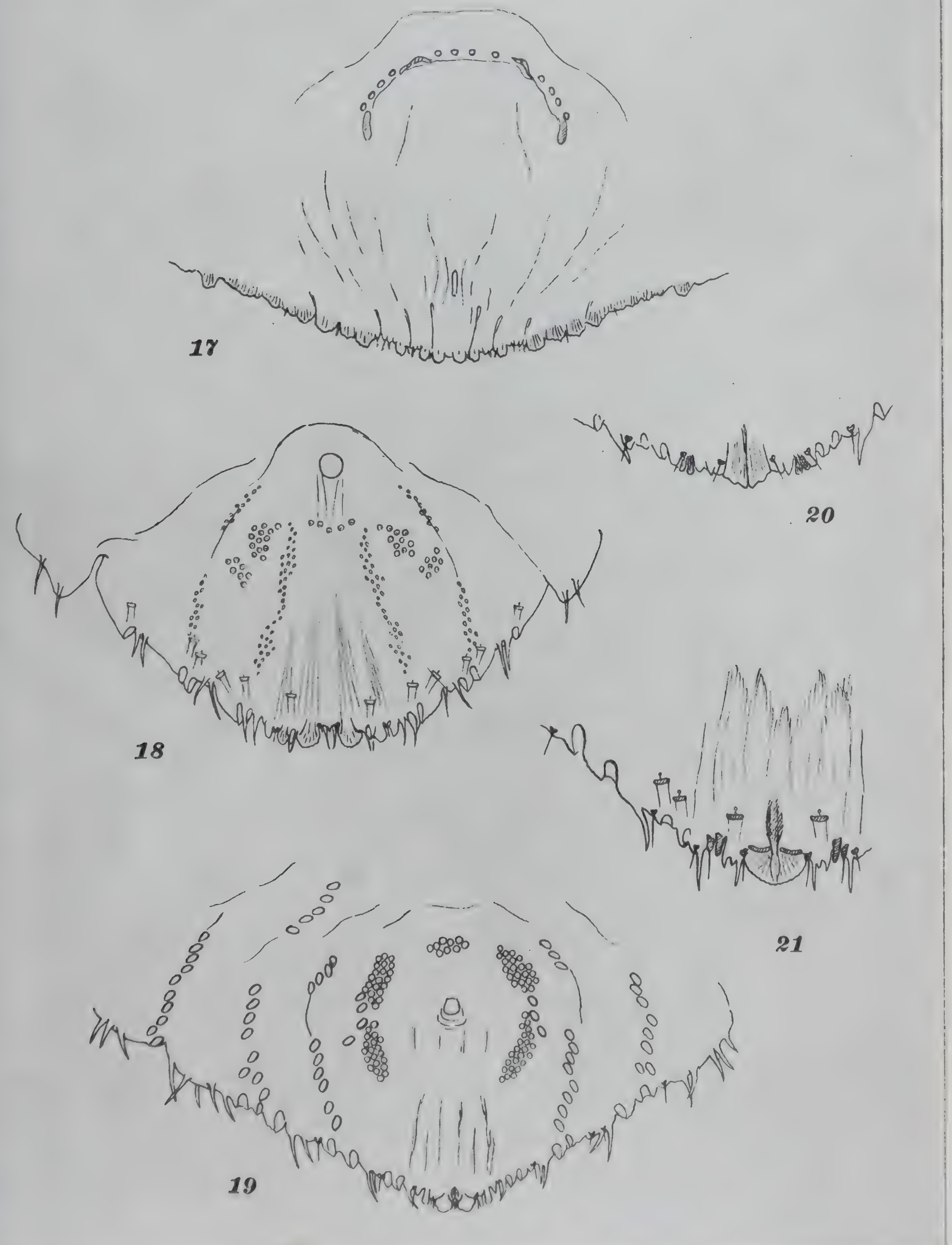


PLATE V.

RED COTTON BUG.

THE RED COTTON BUG (*DYSDERCUS CINGULATUS*, FABR.).

By

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

I.—Description.

The insect discussed in these pages is the representative in India of that class of pest known as "Cotton Stainers," which are specific pests of cotton practically throughout the tropics. Limiting this term to the insects of this genus (omitting therefore *Oxycarænus* which works in a different manner), *Dysdercus suturellus*, Herr. Sch., in the Southern States and West Indies, *D. andreæ*, Linn., in the West Indies, *D. ruficollis*, Linn., in Peru, and other species are recorded as injuring cotton (Ballou, West Indian Bulletin VII, p. 64); Theobald speaks of *D. nigrofasciatus*, Stal., in Uganda, (Entomologist, 1906, p. 27), while Vosseler in German East Africa mentions *D. superstitiosus* and *D. fasciatus* as pests of cotton (Der Pflanzer, 1906, p. 358). *D. sidæ* and *D. cingulatus* in Australia, and *D. cardinalis* in Africa, are also enumerated by Kuhlgatz (Mitteilungen aus dem Zoologischen Museum zu Berlin, III, p. 31, 1905) as injurious to cotton.

These species are only a portion of those constituting the genus, and form a well-marked and distinct class of pests which are injurious to cotton and to some other *Malvaceæ* which have oily seeds. In these pages, we discuss the Indian species, *D. cingulatus*, Fabr., solely with reference to its occurrence in India exclusive of Burma. Details of the life history and

occurrence of other species will be found in the papers mentioned; there is a bibliography at the end of Ballou's paper in the West Indian Bulletin.

Dysdercus forms part of the family *Pyrrhocoridæ*, which is characterised by the absence of ocelli (cf. *Lygæidæ*), the insertion of the antennæ on the side of the head (cf. *Coreidæ*), the straight rostrum and absence of cuneus or embolium to the hemelytra. The female has the sixth ventral segment entire at the base and so falls in *Pyrrhocorinæ*, the hemelytra are entire and the apical angle of the corium is acute; the last characters distinguish the genus from other Indian genera. Within the limits of India proper, there are but three species recorded; *D. olivaceus*, Fabr., is a doubtfully distinct species recorded from "India Orientalis" and probably simply a variety of *D. cingulatus*, Fabr.; *D. evanescens*, Dist., is recorded from Sikkim, the Khasi and Garo Hills, Burma and from the Bor Ghat, Bombay; we have it also from Chapra (Mackenzie collection); it is at once distinguishable by the paler yellow colour and by the brown, not black, colour of the membrane of the hemelytra. *D. cingulatus*, Fabr., is thus described by Distant:

879. *Dysdercus cingulatus*, Fabr. (Cimex) (Syst. Ent., p. 719) (1775);

id. (*Lygæus*) Ent. Syst. iv., p. 153 (1794).

Ochraceous; head, rostrum, anterior transverse callosity and lateral margins to pronotum, and body beneath sanguineous; antennæ, apex of rostrum, scutellum (sometimes concolorous), a discal spot to corium, membrane and legs black: anterior collar to pronotum, anterior margin to prosternum, posterior margins of sternal and abdominal segments, and spots near coxæ creamy-white; extreme base of first joint of antennæ sanguineous.

Var. a. Anterior pronotal callosity black, not sanguineous.

In both forms the colour above also varies from ochraceous to stramineous, and beneath from sanguineous to dark purplish.

Length 9 to 16 millim.

Hab. Sikkim, Assam, North Khasi and Garo Hills (Chennell); Karachi; Calcutta, Bangalore (Cameron).

II.—Life History.

The Egg.—A single egg is an oval yellowish white structure, a little over one millimetre in length; when freshly laid, it is soft, but the shell soon becomes moderately hard. The surface is smooth, unsculptured and shiny. (Plate V, fig. 1).

The eggs are laid in a loose, irregular mass, poured out one after another and devoid of any external gum to bind them together. In the field they are laid in cracks in the soil, under loose leaves or other debris, at the roots of plants; when laid in the soil, the female scratches loose soil over them, not only as a protection but with the object of preserving them from becoming dry. Exceptionally eggs are laid on the bract of a cotton boll; they are also laid in the lint of open cotton bolls; cotton that is picked at the commencement of the cold weather may contain eggs which hatch quite normally, the cotton thus being infested with the bugs which continue their development in the picked seed-cotton. The places selected for egg-laying are probably such as combine a hiding-place with the right moisture conditions; eggs laid in captivity in a dish or box are apt to dry or become mouldy as a result of insufficient or excessive moisture. So also direct sunlight destroys the eggs, the dry hot air of May killed all eggs exposed to it and, in a desiccator, the eggs dried up. In the big cages in the insectary the bugs laid eggs in cracks prepared for them, and after laying them, the bugs themselves covered them with earth.

The number of eggs laid by reared females at one time varies from 80 to 100; this is in captivity in as natural circumstances as possible. Dissection shows that each ovary consists of eight to ten egg-tubes, containing each eight to ten developing eggs: apparently about half of these are laid and then the remainder develop, about fifty eggs being laid as a second batch some weeks later. Eggs hatched in seven days in warm, moist weather; the newly-laid egg is whitish yellow, and it becomes yellow after a short time. Before hatching three red spots are visible, the eyes and a dorsal abdominal spot; the

egg-shell is also loose and not tightly stretched. The egg-shell opens along the mid-dorsal thoracic line, no special device being known.

Nymphs.—The nymph passes through five instars, becoming mature at the fifth moult. After hatching, the nymph is about 1·5 mm. long, of a yellow colour; it is slightly flattened and the dorsum is convex; the antenna is yellow-white, with four joints, the basal joint largest; the proboscis is four-jointed, extending to the middle of the abdomen; the tarsi are two-jointed. Within twelve hours the colour of the antennæ, legs and beak deepens to red and in 24 hours the body is also red.

After the first moult, the nymph measures 2 mm.; the lateral margins of the body turn up a little; the terminal antennal joint is swollen; the proboscis at first stretches beyond the apex of the abdomen, but the abdomen grows larger and covers it. During this instar the apertures of the odoriferous glands on the abdominal dorsum become perceptible.

In the third instar, very tiny fuscous pads appear on the meso-thorax and metathorax, being the first external rudiments of wings. The bug measures 4 mm. Three red-brown spots along the abdomen above, and one anal spot are visible; three white lateral spots and two white bands on the abdomen appear during the instar, and a white spot opposite each coxa.

After the third moult, the length is 6 mm.; the wing pads are 1 mm. long; three prominent white spots appear dorsally and the white spots and bands below the body become more marked. Late in the instar, the dorsal white band behind the head appears, as well as two additional ventral white bands on the abdomen. The female nymph is now larger than the male.

In the last instar, the length is eight to nine mm. The white collar becomes complete; two additional white abdominal bands appear and the former ventral spots become complete bands. The final moult then takes place and the adult appears, the male 13 mm., the female 15 mm. long.

All reared in captivity have the markings described, but are sanguineous in colour, and the living insect is sanguineous and

not ochraceous (*vide* Description on page 48). The insects, though externally mature, are not sexually mature for some time; in the insectary, bugs emerging as adults on November 21st, paired on 14th December; in warm weather in the field, this period is shortened. Coupling is in opposition, as in all Rhynchota; it is a lengthy process occupying 36 hours when the pair is undisturbed and they walk about and feed freely during the process.

Oviposition takes place some days later and the females can be distinguished at once by the greatly distended abdomen; they feed freely during the interval between emergence as adult and oviposition; the weight of a newly hatched nymph is about $\frac{1}{100}$ of a grain, the newly emerged female about ·8 grain, the fertilised female before oviposition about 3·3 grains. The periods of the moults and the totals are shown in Tables A. and B. The variations in individuals of three batches is shown in Table C.

Table A.

No.	Hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.	REMARKS.
1	7-X	10-X	21-X	27-X	2-XI	18-XI	......
2	7-X	10-X	18-X	25-X	2-XI	21-XI	......
3	7-X	10-X	21-X	29-X	9-XI	2-XII	......
4	7-X	10 X	24-X	2-XI	......	......	Died 25-XII
5	7-X	11-X	20-X	27-X	5-XI	28-XII	......
6	8-X	11-X	19-X	25 X	3-XI	26 XI	......
7	8-X	12-X	23-X	1-XI	22-XI	25-XII	......
8	8-X	11-X	20-X	27-X	7-XI	25-XII	......
9	8-X	11-X	21-X	30-X	......	......	Died 25-XI
10	8-X	11-X	19-X	27-X	4-XI	......	Died 22-XI
11	9-X	13-X	20-X	25-X	4-XI	8-XII	......
12	9-X	14-X	25-X	6-XI	15-XI	27-XII	......

Table B.

Eggs laid.	Eggs hatched.	Bugs attained maturity.	Period in days.
30-IX	7-X	18-XI	49
30-IX	7-X	28-XII	89
1-X	8-X	26 XI	56
1-X	8-X	25-XII	85
2-X	9-X	8-XII	67
2-X	9-X	27-XII	86

Table C.

Bugs hatched from eggs.	The first of them attained maturity.	The last attained maturity.	Range of the period in days.
7-X	18-XI	28-XII	42-82
8-X	26-XI	25 XII	49-78
9-X	8-XII	27-XII	60-79

III.

The habits of the nymphs are similar to those of the adult and all stages are found together. Normally these insects feed more or less gregariously by day, exposing themselves freely on their food plants and forming very conspicuous red clusters. This habit agrees with the distinctly warning colouration and the defensive odour, the bug advertising itself as inedible in every possible way. They are active, running freely about: the adults seldom fly and the wings are but little used. Food is derived by suction, fine setæ of the proboscis entering the tissues of the plant, enabling the sap to be pumped out. Normally these bugs feed on such parts of the plant as contain much sap or mucilage, or extract the oily matter from seeds. In India, the cotton boll is the normal food where it can be obtained; the green boll is pierced, the sap drawn out from the moist developing lint; this is the typical form of food and green bolls are most commonly attacked. The mucilaginous pods of the Ochro or Bhindi (*Hibiscus esculentus*) are preferred to cotton bolls, and when this is available, the bugs cluster in masses on them. Bhindi is far more infested than cotton if the two are grown side by side. When the bolls open, the bugs feed readily on the seeds so long as they are soft; when the seeds have become hard and dry outside, the bugs are unable to suck them. Another favourite food plant is the Silk cotton, or Simul (*Bombax malabaricum*), both on account of the sap in the developing silky fibre and on account of the seeds when the pod opens. Immense quantities of the bugs are found on this tree in March-April, when the pods are developing, and they fall or come down the tree to feed on

the seeds when the pods open and fall. Such fallen seeds are covered with clusters of these insects in all stages, their beaks firmly attached to the seed. We know of only one other distinct "food plant," the hollyhock cultivated in gardens; the bugs feed freely in its flower buds. Other *Malvaceæ* are probably attacked, and there are reports of the musk-mallow (*Hibiscus abelmoschus*) and the garden Hibiscus as being injured.

Besides these special food plants, from which the bug can derive sufficient food to breed, it is found on a variety of other plants and feeds on them; but we have been unable to find any case when the bug really attacks them and can derive enough food from them to be able to breed. Weeds or plants with fleshy leaves or with soft fruits are fed upon and, other food failing, the bug supports life upon them. Wheat-ears are sucked out when the grain is developing; the soft fruits of the Tipari (*Physalis peruviana*) are sucked; a weed (*Solanum verbascifolium*) which fruits in May is then infested. The bug is found on maize, *bajra* and other cereals, but is not a pest on them, and these are casual food plants.

Damage.—It is not at once obvious in what way the Red Cotton Bug damages the plant and careful experiments with plants under control have been carried out to determine this. In the first place, the bugs reduce the vitality of the young shoots by sucking them; this very rarely occurs in the field and is, we believe, a negligible form of damage. The main attack is on the green boll; the sap is extracted from the mass of developing lint, or if the boll is young enough, from the whole developing boll; the result is a small boll, containing bad fibre, which opens prematurely and is practically worthless. Badly attacked green bolls allowed to mature do not form to large bolls which open normally and bear a mass of good fibre. Very small bolls thus attacked fall off.

The attack on the riper bolls is less injurious to the lint, but if the boll opens, the bugs suck out the seeds and they dirty the lint with excrement; further, the young either hatch there, when eggs are laid, or they gather in the lint to feed on the seeds and

picked cotton frequently contains young nymphs which get crushed and stain the lint. We believe this last to be the only way in which the lint gets stained red and the normal damage to cotton in India is not by staining. The bug would be erroneously described as a "Cotton Stainer," unlike one of its American allies whose excrement stains the cotton. Damage to cotton seed is very common, but it is difficult to know how much to assign to this insect and how much to *Oxycarænus lætus*, Kby., the Dusky Cotton Bug. Sucked out seeds are useless; their oil content is small, the germinating power is gone, and section of such seeds shows a shrivelled dark mass instead of a plump healthy seed. Seeds are thus sucked out either while developing in the boll or after the boll opens, before the seeds are fully hardened. In a normal year, the cotton seed at Pusa contained about ten per cent. of useless seed which failed to germinate, and this loss is directly attributable to Red Bug. Samples of seed obtained from ginning mills in the Punjab gave a percentage of bad seed from 10 to 55, but a large part of this damage is due to *Oxycarænus lætus*, Kby.

Occurrence through the year.—When food is available, breeding takes place so long as the weather is warm. The usual sequence in Pusa is, extensive breeding in April—May on *Simul* (silk cotton tree), in June—July feeding on miscellaneous plants such as Hibiscus, *Bhindi*, or *Solanum verbascifolium;* August to November, breeding on cotton; with the setting in of the real cold weather, the bugs all seek shelter; they have been found under fallen leaves, in grass, deep down in cane stools; a great number of nymphs found shelter in the thick edging of a lawn, coming out on warm days to feed. Hibernation is not a long period of rest as in other insects, but probably has a very close relation to temperature, a fall of temperature to a definite point causing dormancy. When cotton was growing continuously at Pusa, and there was almost always some in boll, the breeding of this pest continued unabated except in January and February.

In most parts of India, breeding is of necessity confined either to the cotton season, to the season when *Bhindi* is in pod

or to the season when *Simul* is in bearing. The long, dry, hot weather is passed in shelter or feeding on any available plants, the cold weather in a dormant state, and the insect feeds and multiplies when food is available with a sufficiently high temperature.

The adult is long-lived under ordinary circumstances, if food is not too plentiful. In the insectary, bugs were kept alive for four months ; there is good reason to believe that bugs, in the field, keep alive from November to June if they cannot breed. Plentiful food means breeding, exhaustion of male and female, and death. Insufficient food prevents breeding, the life continues with such sustenance as can be got from casual food plants, and, with the advent of good food, the sexual organs mature, mating takes place and the adults die, the females being the longer lived as they wait some days to mature and lay the eggs.

Enemies.—A Tachinid fly lays an egg on the body of the adult, the maggot feeding in the base of the abdomen and subsequently coming out to pupate in the soil, the host dying. In no case has the percentage parasitised been a high one, nearly ten per cent. being recorded in one case ; as a rule, parasites are not found, and so far as we are aware this parasite is a very occasional check. The common Reduviid bug (*Harpactor costalis*, Reut.) has been observed to feed upon these bugs in the field and may destroy them to a considerable extent.

Birds.—Mr. Mason, Supernumerary Entomologist, has found that the black-headed oriole (*Oriolus melanocephalus*) eats the Red Cotton Bug, which forms from 50 to 75 per cent. of its food from January to June, most being eaten in the cold weather. In the gizzard of the common hawk cuckoo (*Hierococcyx varius*), Mr. Mason found this insect in very small percentage, and he also observed that a nut hatch (probably *Sitta frontalis*) brought them to its young in the nest.

Reports.—This insect was reported from Cawnpur as injuring vegetables (Ind. Mus. Notes, I, p. 212) ; from Cossipore as injuring musk-mallow (*Hibiscus abelmoschus*) ; from Seringapatam as injuring cotton (loc. cit. II, p. 166) ; from Poona as injuring

cotton (loc. cit. III, p. 57), Simul tree (loc. cit. IV, p. 37); the late Mr. W. Gollan reported it as feeding on *Hibiscus esculentus* in Saharanpur; the Superintendent of the Dharwar Farm reported it on cotton in November 1905; Mr. F. W. Tytler found it on cotton in Belgaum in July 1904; Mr. Murray sent it in from Kurnoul, Tirhoot, in June 1904 as a cotton pest; the Berar General Trading Company reported serious damage to Egyptian and Bombay cottons in November 1904. It is noticeable that no report has been sent by any District Officer, showing that serious damage to the cotton crop is never observed and, actually, the damage done is not associated with this insect by the ryot. We have seen this cotton pest in every cotton growing district in India we have visited; it is common in the Punjab; its occurrence at Cawnpur has been several times reported or seen; it is common throughout Tirhoot, and in Bengal; the Entomological Assistant in the Central Provinces records it from Nagpur, Buldana, Bilaspur and Balaghat, while we have seen it at Amraoti and Raipur; it is abundant in Gujarat, at Poona, Dharwar and Belgaum in the Deccan; in Madras it is plentiful, and we have seen Gogu *(Hibiscus cannabinus)* badly infested at Coimbatore. We believe it to be a general cotton pest throughout India where this crop grows.

Treatment.—The simplest and most effective method found after much trial has been described elsewhere (*Indian Insect Pests*, p. 104, *Agricultural Journal*, I, p. 53). When cotton was first grown on the Pusa Experiment Farm, this bug was very bad indeed; the plants were covered with the bugs, and as there was over 20 acres thus affected, there was every opportunity of testing remedies. They worked down to the simple method of collection by hand, each coolie having a winnow in one hand and beside him a kerosene tin containing water and a little kerosene. Holding the winnow below the bolls or shoots on which the bugs were massed, a sharp shake dislodges the bugs into the winnow; a quick jerk brings them to one corner whence they are emptied into the tin. This method has since been in use when required. Naturally, all the insects are not obtained but the proportion is

so high that it is practical extermination. Trials were made, on bugs on plants under large cages, of spraying; the following were the results:—

McDougal's Sanitary Fluid.

(*a*) 1 in 16. All sprayed dead in an hour.

(*b*) 1 in 32. All dead next day.

(*c*) 1 in 64. Nearly all dead next day.

(*d*) 1 in 100. No immediate effect. Half dead in 15 hours.

McDougal's Insecticide and Fungicide.

(*e*) 1 in 32. All dead that were really sprayed.

(*f*) 1 in 64. ,, ,, ,, ,, ,, ,,

(*g*) 1 in 96. Very young nymphs dead.

Crude Oil Emulsion.

(*h*) 1 in 32. No immediate effect. Young nymphs all dead; last instar and adults survived next day.

(*i*) 1 in 64. 80 per cent. alive. Youngest nymphs dead. In every case, except *d. g. h. i.*, damage was caused to the plant, the foliage coming off. If for no other reason than this, spraying is impossible; the strength of insecticide that will kill the bug injures the plant, and, like most big Rhynchota, contact poisons are of little use.

One other fact is worth remark here; when Bhindi (*Hibiscus esculentus*) was grown as a trap crop with cotton, the red bugs gathered in quantity on the green pods of this plant and left the cotton; it was very easy to collect all the insects on *Bhindi* An acre of *Bhindi* was sown with irrigation to provide food for boll-worms; this acre was red with bug and it looked as if every bug on the farm was there. We have observed this elsewhere, and this insect is a more serious pest to *Bhindi* than to cotton *Bhindi* has so great a value as a trap crop for other cotton pests that this is a strong additional point in its favour, where cotton is important. Actually, the hand-collecting method is so simple that it is not necessary to grow *Bhindi* for this pest alone, unless in experimental plots of cotton grown for hybridising or selection.

Explanation of Plate V.

(1) Eggs in a cluster (each enlarged three times).
One egg to the right of the cluster × 6. The enlarged single yellow egg showing the colour before hatching.

(2) The just hatched nymph × 3. To the right of this the young nymph about a day old × 3.

(3) The nymph in the second stage × 3.

(4) The nymph in the 3rd stage × 3.

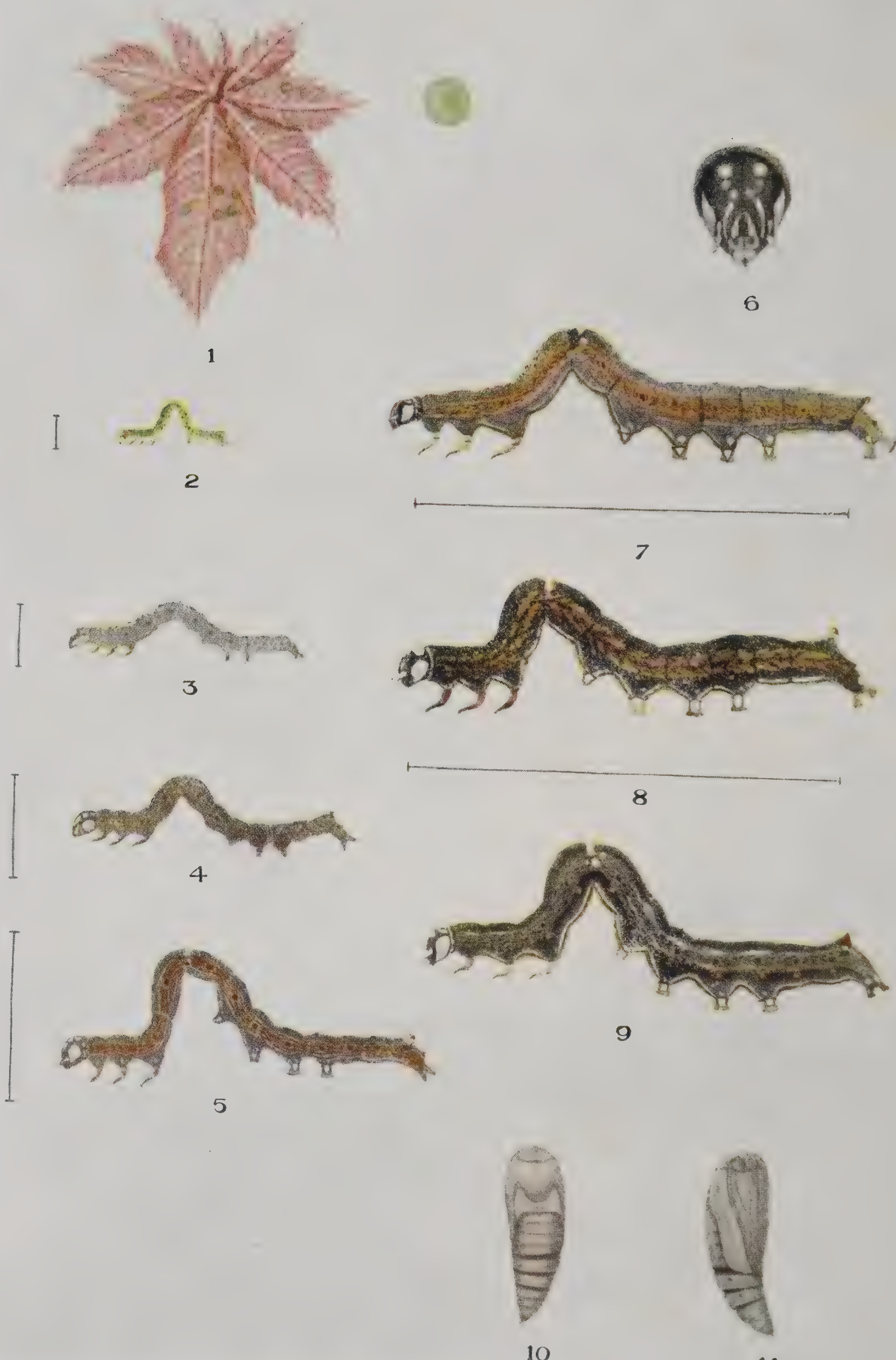
(5) Do. in the 4th stage × 3.

(6) Do. in the 5th stage × 3.

(7) The adult bug × 3.

(8) Ventral view of the adult bug × 3.

PLATE VI.



CASTOR SEMI-LOOPER.

THE CASTOR SEMI-LOOPER (*OPHIUSA MELICERTE*, DR.).

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

I.—DESCRIPTION.

THE genus *Ophiusa* is in the Fauna of India (Hampson) placed in the family *Noctuidæ*, subfamily *Quadrifinæ*. In the same author's later publication, the Catalogue of *Lepidoptera Phalænæ* now in course of publication, the subfamilies are revised and the genus will now stand in the subfamily *Catocalinæ*, the volume of which is not yet published.

As characterised in the Fauna of India, Volume II (1894), the genus is widely distributed, every zoo-geographical region except the Nearctic containing representatives. Forty species are recorded from India, Burma and Ceylon, of which no less than seventeen have a wide distribution in the plains of India and are not confined to the hills. Of these species, the one now under discussion is alone known as an injurious insect; the very distinct species *O. algira*, Linn. (Plate VII, Fig. 5), is rarely found with *O. melicerte*, Drury, on its common food-plant castor, and is the only other species the student of economic insects is likely to find. For the general collector the species most likely to be confused with *O. melicerte* is the widely spread *O. serra*, Fabr. The following is

the synonymy and description of each given by Hampson in the Fauna of India, Vol. II, p. 494 :—

2483. *Ophiusa melicerte*, Drury, Ill., Exot. Ins. i, p. 46, pl. 23, Fig. 1 ; Moore, Lep. Ceyl. iii, pl. 168, Figs. 2, 2a, b (larva) ; C. & S., No. 2624.
Noctua tigrina, Fabr. Spec Ins., p. 218.
Achæa catella, Guen, Noct. iii, p. 247.
Catocala traversa, Fereday, Trans. N. Z. Inst. ix, p. 457, pl. 17.

Pale reddish brown. Fore wings with the markings usually prominent, but sometimes almost obsolete ; a short subbasal waved line ; obliquely waved antemedial and excised postmedial lines, often with black suffusion inside them ; a speck at end of cell ; a diffused rufous band beyond the postmedial line. Hind wing black with medial white band ; three large white spots on outer margin ; the cilia whitish. Underside suffused with grey ; fore wing with an oblique white postmedial band not reaching the costa ; two crenulate medial lines on each wing. (Plate VII, Figs. 3, 4.)

Expanse 60—70 millim.

2484. *Ophiusa serva*, Fabr. Syst. Ent., p. 593 ; Moore, Lep. Ceyl. III, pl. 169, Figs. 4, 4a, b ; C. & S., No. 2628.
Noctua vulpina, Fabr., Ent. Syst. iii, 2, p. 39.
Noctua mercatoria, Fabr., Ent. Syst. iii, p. 62.
Achæa ino, Hubn., Verz., p. 269.
Achæa fasciculipes, Wlk., Cat. xiv, p. 1400.
Achæa nubifera, Moore, P. Z. S., 1877, p. 609, pl. 59, Fig. 9 ; C. & S., No. 2626.

Differs from *melicerte* in being usually more uniform, pale brick-red, with the markings of the fore wing indistinct ; the antemedial, medial, and postmedial lines are waved and often double. Hind wing with the medial band less prominent ; the marginal spots smaller, that at anal angle obsolescent.

The form *fasciculipes* is large and dark. Expanse 50—76 millim.

Distribution.—Hampson gives the distribution as "Ethiopian, Oriental and Australian Regions." We may fairly characterise the species as one that occurs throughout the Himalayas, Assam and Burma, throughout the hilly forest areas of India proper and over the whole cultivated areas of India, with the exception possibly of former desert areas now under irrigation, as in the Canal Colonies of the Punjab. There is little use in giving a long list of localities; the records of the literature, the specimens in the Indian Museum and Pusa collection, and the genuine reported occurrences of this pest in Indian Museum Notes and during the past four years show that it is practically universal over this area in India.

II.—Life History.

The egg is of a blue-green colour, round, a little less than one millimetre in diameter (about $\frac{1}{30}$th of an inch); it is of the usual Noctuid type with ridges and furrows radiating from the circular depression at the apex. Before hatching, the egg becomes paler, the blue-green tint giving place to the paler colour of the developing larva. An infertile egg remains the original colour till it shrivels, while an egg laid in cold weather remains blue-green for some days. Eggs are found on the undersurface of the leaves of the food-plant, not as a rule in any number together, but each egg laid singly. (Plate VI, Fig. 1). The number laid on each leaf varies greatly, from one to five or six having been found. They are by no means easy to find and would not be seen unless one had clear evidence that moths had been on the plants egg-laying. As the moths lay at night, a very large number of eggs may be laid on a young crop without there being any indication whatever of the fact, and this accounts for the apparently amazing way in which swarms of these caterpillars are suddenly found to occur in a field. In the insectary, C. C. Ghosh found that eggs hatched in two days in September, in four to five days in November.

Larva.—The larva emerges by biting a round hole in the egg-shell; it then makes a meal off a part or the whole of the empty white eggshell and is then ready to commence feeding on the plant.

The eggs being laid on the young leaves, the tiny larva finds abundance of nutritious food and is able to start at once on the life of voracious greediness exhibited in this stage. When in the first instar, the larva is slender, about one-seventh of an inch long (3·5 mm.) ; the head is light brown, shiny, larger than the individual segments. The prothorax has a brown shield ; the rest of the body is a yellowish green, the latter colour more intense when the green of the contents of the alimentary canal shows through. On each segment are small black tubercles bearing short hairs ; the first two pairs of suckerfeet are undeveloped and the gait is that of a typical looping caterpillar. (Plate VI, Fig. 2.) During this instar, the lower epidermis of the young leaf forms the food of the larva, which does not eat the leaf from the edge as larger larvæ do.

In the course of two to three days the larva moults, abstaining from food for some hours beforehand. In this moult as in later ones, the head case is cast separately ; the cast skin of the body is commonly eaten. After this moult, the length is about one-third of an inch (8 mm.). The head is now darker in colour, with white patches ; the body is of darker colour but with a whitish bloom which gives it the greyish appearance shown in Plate VI, Fig. 3. The dorsal and the two dorso-lateral black tubercles are more distinct, the proleg on the fourth abdominal segment appears as a distinct process ; the two small tubercles on the anal hump appear as black processes. The larva is now able to nibble portions of the leaf and is not confined to the epidermis ; it is also more active and moves about freely. This instar lasts for about two days, when the second moult is undergone. The larva now has a length of half an inch ; the colour is a grey-black with the black tubercles and with faint white on the sides of each segment. (Plate VI, Fig. 4.) The colouring varies considerably and in some specimens the first interrupted red lateral line appears and a small black patch on the second abdominal segment. The first pair of prolegs on abdominal segment three is shown as a hump, and the second pair is almost fully developed. This instar lasts for two to three days, the larva feeding voraciously on the tissue of the leaf, biting in from the edge towards the mid-rib.

After the third moult the colouring characteristic of the mature larva is found, but the development of this colouring is restrained in some instances, the colouring of the third instar is retained and an extra moult is undergone. This is a curious fact ; the records of the bred larvæ show that in some a supplementary third moult is undergone one or two days after the third, while in others, this does not take place ; in both cases the result is the same, the larva having the same appearance after the third moult, where there are only five as after the fourth where there are six. The larva measures nearly one inch (22 mm.), the first pair of prolegs is better developed, the second almost functional ; the anal tubercles are reddish and more distinct ; the white marks on the dark head are more conspicuous ; the red stippling on the dark grey body is more extensive and a black transverse band occurs at the second abdominal segment at the apex of the loop when the larva walks ; this is not visible when the body is straight.

The period between the third and fourth (or fifth) moult lasts for four to seven days : the fourth moult is then undergone and the fully developed larva is seen. This has a length of $2\frac{1}{2}$ inches (60—65 mm.) ; the head is black with the white patches shown in Plate VI, Fig. 6 ; the first pair of prolegs is larger but not functional ; the second, functional ; the apex of the loop is conspicuously black with a red spot on it ; anal tubercles are red. The colouring varies and is not capable of accurate description ; there are grey larvæ with lateral red or brown stripes, and there are black larvæ with lateral white stripes. A median longitudinal red line occurs in some specimens and the amount of red and white stippling varies immensely. The principal types of colouring are shown on Plate VI, Figs. 7, 8, 9.

Full grown larvæ feed in from the edge of the leaf to the mid-rib, stripping the leaves entirely and very soon leaving nothing of the plants but the bare stalks. They are very active and extremely voracious ; singly they behave like ordinary caterpillars ; when in numbers, they are sufficiently gregarious to give the idea that they act in concert and move in swarms. These larvæ are extremely conspicuous on the plant and rest openly on

the leaf, clasping the margin firmly and exhibiting the whole of the brightly covered body and the noticeable anal tubercles. This instar lasts for four to five days, the larva eating freely and then the preparation of the cocoon commences ; in most cases this takes place in the soil ; the full grown larva descends to the ground and seeks a spot where the soil is loose or where it can hide among fallen leaves, or the rubbish at the edge of a field ; it hides there on the surface of the soil and prepares a loose cocoon of coarse silk, to which particles of soil adhere readily, giving the whole the appearance of a lump of soil. (Plate VII, Fig. 1). In some cases pupation takes place on the plant, the leaf being folded over, the cocoon formed in the fold (Plate VII, Fig. 2). This takes place apparently only in warm weather, when not only is the pupa sure to transform, but when it will do so quickly. Normally, even in warm weather, pupation takes place on the soil. It also takes place in the rains when the soil below the plant is very wet or there is standing water.

The preparation of the cocoon and the subsequent rest occupies from one to four days, after which pupation takes place ; this is the last and final caterpillar moult ; the body shrinks and shortens, the anal segments become tapering ; the skin bursts along the head and prothorax, the chrysalis wriggles out ; the skin coming off with the head case and being pushed to one end of the cocoon. The chrysalis is about one inch long, with two movable abdominal segments (Plate VI, Figs. 10, 11) ; it is at first brown, but becomes covered with a fine whitish bloom which gives it a peculiar greyish look ; the apex of the abdomen is roughened with 8 curved hooklike processes which are twisted firmly into the strands of silk. Fig. 1.

The pupal stage lasts for ten days to a fortnight in warm weather, but may occupy months in cold weather. The moth emerges from the pupa with soft crumpled wings, and pushes straight through the thin cocoon, emerging at the surface of the soil where its wings dry and harden.

The moths are wholly crepuscular in habit, resting by day in hiding on the soil, among fallen leaves, etc., and coming out at dusk. Where they are abundant, they mate the first night, the

PLATE VII.

CASTOR SEMI-LOOPER.

males die soon after and the female commences egg laying the next night. An isolated moth can, however, wait for a long period and moths have been kept alive in the insectary for periods varying

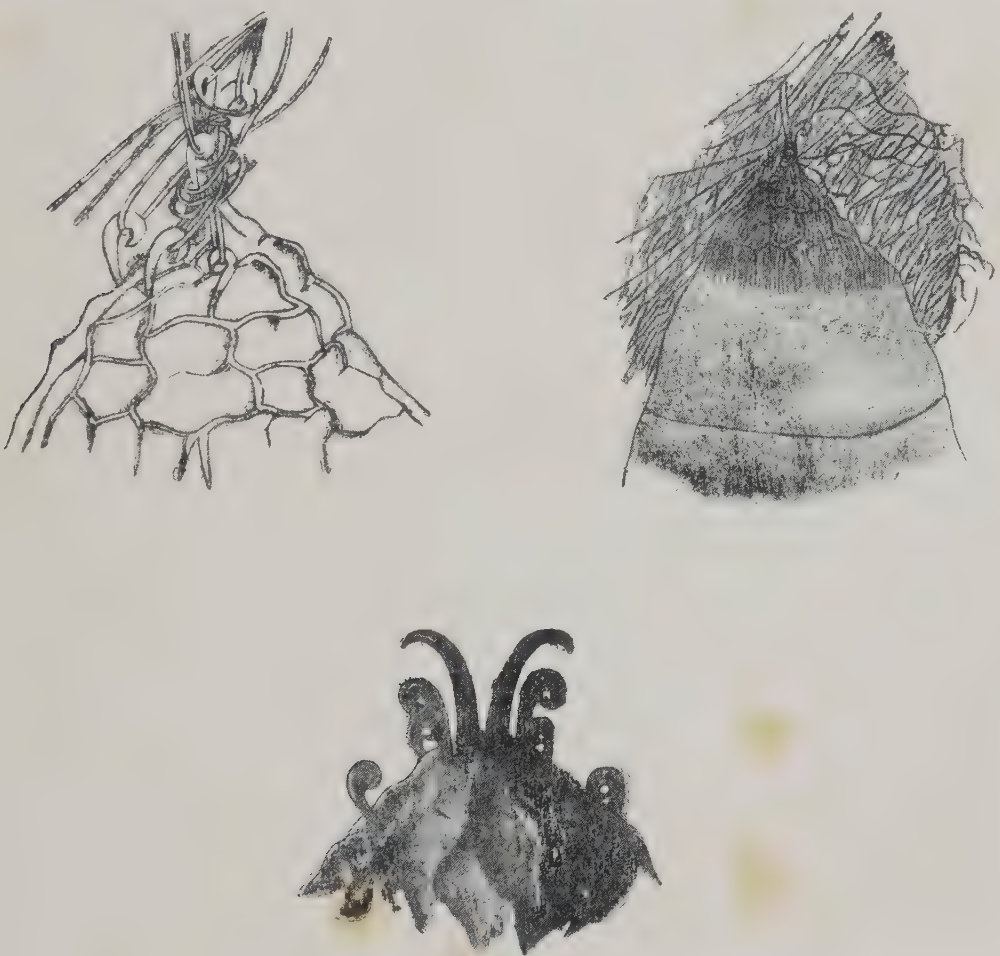


FIG. 1.—THE APEX OF THE ABDOMEN OF THE CHRYSALIS AND ITS METHOD OF ATTACHMENT.

from 11 to 35 days if given shelter and syrup for food. Normally, as soon as fertilisation has taken place, the female commences to lay her eggs, provided food is available. It has not been possible to ascertain what takes place in the field when food plants are not available ; in captivity, an unfertilised female lives some time and only deposits eggs before death ; in the field it is probable that both sexes can live long periods if mating does not take place. What happens to a fertilised female cannot be ascertained, since in captivity she lays eggs ; but it would be interesting to know whether a fertilised female in the field can wait till she finds food or must deposit her eggs. It is at this period probably that the influence of this great natural check is felt.

In captivity, females laid eggs during a series of nights ; C. C. Ghosh counted 180 laid in the first five nights, then 30, 59, 30, 24, 19 on successive nights, after which she died and was found to have still 32 eggs in her body. Somewhere about 450 is the number of eggs laid by a single moth, and practically all these eggs have been found to hatch, even in captivity. The following tables give the exact periods observed in the insectary for different stages.

The following gives typical periods of the egg stage :—

Eggs laid.	Eggs hatched.	Duration in days.	
27-IX. (Night) ...	30-IX. (Morning) ...	About 2 ...	Left on the plant.
3-X. (Night) ...	6-X. (Morning) ...	About 2 ...	Do.
3-X. (Night) ...	6-X. (Morning) ...	About 2 .	Kept in a desiccator.
7-X. (Night) ...	10-X. (Noon) ...	About 2½ ...	Left on the plant.
25-X. (Night) ...	28-X. (Night) ...	About 3 ...	Do.
4-X. (Night) ...	8-XI. (Night) ...	About 4 ..	Do.

The dates of moults. etc., are given in the following table :—

Hatched.	1st Moult.	2nd Moult.	3rd Moult.	S. 3rd Moult.	4th Moult.	5th Moult.	Duration of larval stage in days.
30-IX	3-X	5-X	7-X	8-X	10-X	15-X	15
,,	,,	,,	,,	...	9-X	14-X	14
1-X	4-X	6-X	8-X	...	11-X	15-X	15
2-X	,,	,,	,,	10-X	11-X	15-X	13
10-X	12-X	14-X	16-X	...	18-X	22-X	12
8-XI	12-XI	15-XI	18-XI	....	21-XI	30-XI	21

The table following shows the marked increase of duration due to cool weather :—

Larvæ hatched.	Larvæ pupated.	Duration in days.
30-IX	11-X	11
5-X	14-X	9
7-X	17-X	10
29-X	12-XI	14
9-XI	30-XI	21

Pupa.

Larva pupated.	Moth emerged.	Duration in days.
12-X	22-X	10
14-X	25-X	11
20-X	31-X	11
21-X	5-XI	15
12-XI	7-XII	25
30-XI	6-I	37
30-XI	25-I	56
1-XII	30-I	60
16-XII	29-I	44

The following table gives a number of periods observed from egg to imago :—

No.	Egg laid.	Egg hatched.	Larva pupated.	Moth emerged.	Duration in days.
	28-IX	30-IX	11-X	21-X	23
)	28-IX	30-IX	15-X	26-X	28
3)	29-IX	1-X	12-X	22-X	23
(4)	29-IX	1-X	15-X	27-X	28
(5)	30-IX	2-X	12-X	23-X	23
(6)	30-IX	2-X	15-X	25-X	25
(7)	3-X	5-X	14-X	25-X	22
(8)	7-X	9-X	19-X	1-XI	25
(9)	8-X	10-X	21-X	5-XI	28
(10)	26-X	28-X	12-XI	4-XII	39
(11)	26-X	28-X	12-XI	7-XII	42
(12)	5-XI	9-XI	30-XI	6-I	62

The above tables show the periods for individuals ; to emphasize the fact of the variation found in individuals, the following table shows the variation in the periods of the pupa stage of batches :—

Larvæ pupated.	Moths emerged.	Duration in days.	
16 to 22-XI ...	15-XII to 8-I ...	29 to 47 ...	Observed outside in Insectary compound.
26 to 30-XI ...	6-I to 25-I ...	41 to 56	
28-XI to 1-XII ...	6-I to 30-I ...	39 to 60	

Occurrence throughout the year.—We have endeavoured to piece together the whole of the available information and to ascertain the occurrence of this insect at the different seasons of the year. In Pusa, hibernation takes place in the open from November or December to March or May ; the tables quoted above show moths emerging at different periods in December and January, but this was in cages in the building ; actually, the bulk of the chrysalides which pupated more naturally emerged all together in May, and the first brood of caterpillars was found in early June. On the other hand, moths have been captured and some emerged in captivity in March.

So far as our present experience goes, the variations of climate in Pusa are sufficient to account for this ; the cold months of December, January and February are not even uniformly cold or damp ; the succeeding months may be intensely dry and hot, cooler

and moister, or a combination of both; and in the three seasons for which records are available, the behaviour of insects hibernating has varied very greatly from year to year. I believe, that normally this species rests as a pupa in the ground until shortly before the rains, *i.e.*, till May, but that exceptionally it emerges in March.

The rains, June to October, is the period of activity and the moths in June lay eggs, and broods follow until October; the brood in November normally hibernates in the pupal stage. There would, therefore, be about four broods during the rains, followed by a hibernation brood and, for Pusa, this sums up the year.

What is said here applies to the main mass of the insects; but what happens, for instance, to the stragglers of the November brood, the late ones that are not ready to pupate, the early ones that pupate too soon and come out? Quite apart from the insectary records, we find this in the field, and there must be a number that behave differently; whether a moth that emerged too soon could live through the winter cannot be proved, but it is possible. In any event, it must be remembered that broods are not regular, that there is a considerable amount of variation, and that it is very likely nature's greatest check on this fecund insect that only those that hibernate as pupar shall be able to live through the cold weather.

It is noteworthy that hibernation as a *resting larva* is not observed.

In no other locality has it been possible to study this pest so closely as to trace its course through the year. Ratiram Khamparia, the Entomological Assistant, at Nagpur (Central Provinces), has recorded the occurrence of the pest at Nagpur in the months of July, August, October, 1905, and June, August, October, 1906.

All the breeding records and reports give the rainy months as the season of activity, and we are justified in asserting that in the plains of India, the active season is the moist warm weather, that cold weather is spent normally as a resting pupa, as is dry hot weather. Thus the report from Madras of damage in January is natural, since that month is warm and fairly humid in South India.

Food.—The food-plant of this insect is Castor (*Ricinus communis*). It also feeds upon the wild Euphorbiaceous plant, Dudhi (*Euphorbia pilulifera*). In Dehra Dun, it is reported to have fed on the tallow tree (*Sapium sebiferum*), and on tea (Ind. Mus. Notes, III, 3, p. 112), but the latter is an exceptional food-plant. The various crops reported to be attacked in Indian Museum Notes, Vol. II, p. 159 are, I think, errors.

In the insectary, C. C. Ghosh determined the weight of food as follows :—

The daily weights of three larvæ and of their excrements are given below. The quantity of food eaten by two of them was also noticed. A weighed quantity of green leaves used to be supplied to each, and the quantity left or not eaten was weighed the next day after about 24 hours. The weights of food eaten were calculated by taking into consideration the loss in weight due to evaporation of the same quantity of green leaves kept similarly. Still they should be taken as approximate. The weights of the larva, pupa or moth, and of excrements are given as they were found every day :—

First Larva.

Date.	Weight of food eaten in grains.	Weight of larva in grains.	Weight of excrements in grains.	
8-XI ...	......	·01	......	Hatched from egg.
11-XI ...	......	·02		
12-XI ...	......	·03	·03	First moult. Weight of excrements up to to-day.
13-XI ...	·2	·08	·03	
14-XI ...	·4	·1	·04	
15-XI ...	·3	·12	·03	Second moult.
16-XI ...	·8	·26	·09	
17-XI ...	1·6	·4	·1	
18-XI ...	1·2	·65	·09	Third moult.
19-XI ...	2·2	1·4	·3	
20-XI ...	2·2	2·6	·6	
21-XI ...	1·2	2·9	·06	Fourth moult.
22-XI ...	6·1	6·3	1·8	
23-XI ...	7·9	10·65	1·8	
24-XI ...	13·2	16·5	6·25	
25-XI ...	16·3	20·2	9·6	
26-XI ...	4·1	17·3	4·8	Began to build cocoon.
27-XI ...	......	15·4	....	
28-XI ...	......	14·7	......	
29-XI ...	......	14	......	
30-XI ...	......	13·4	......	Last moult and pupa. Weight of pupa.
5-XII ...	......	13·1	......	
6-I ...	......	6·3	......	Moth emerged. Weight of moth.

Second Larva.

Date.		Weight of food eaten in grains.	Weight of larva in grains.	Weight of excrements in grains.	
10-X	...	......	·01	......	Hatched from the egg.
12-X	...	......	·03	.....	First moult.
13-X	...	.. ...	·1	·08	Weight of excrements up to to-day.
14-X	...	......	·2	·1	Second moult.
15-X	...	.. ...	·7	·2	
16-X	...	2·8	2·2	·4	Third moult.
17-X	...	7	5	1·5	
18-X	...	9·6	10·8	3	Fourth moult.
19-X	...	25	17·2	16·5	
20-X	...	21·8	17·1	20	
21-X	..	... .	14	......	Pupating.
22-X	...	......	13·6	......	Pupated. Weight of pupa.
27-X	...	......	13·1	.. ...	
29-X	...	......	12·9	... ..	
3-XI	...	....	6·3	......	Moth emerged. Weight of moth.

This caterpillar is seen to have reached a maximum of only 17 grains. Actually, however, it attained a higher weight, but happened to be weighed on that day at a time when its weight was decreasing after having reached the maximum. The weight of a caterpillar increases as long as it eats and then quickly diminishes. During the previous 24 hours this larva ate about 22 grains of food and passed 20 grains of excrements ; it may, therefore, be taken to have attained a maximum weight of at least 20 grains.

Third Larva.

Date.		Weight of larva in grains.	Weight of excrements in grains.	
30-IX	...	·01	......	Hatched from the egg.
3-X	...	·03	......	First moult.
5-X	...	·19	·03	Second moult. Weight of excrements up to to-day.
6-X	...	·3	·05	
7-X	...	·8	·16	Third moult.
8-X	...	2	·4	
9-X	...	5	1·7	
10-X	...	9·2	1·6	Fourth moult.
11-X	...	14·4	7·9	
12-X	...	20·8	20	
13-X	...	16·8	11	
14-X	...	15·4	......	Pupating.
15-X	...	15·1	......	Pupa. Weight of pupa.
23-X	...	14·2	......	
26-X	...	6·3	......	Moth emerged. Weight of the moth.

A larva eats more as it grows and voraciously for a few days before it pupates. Whether the larval stage is short as in summer or long as in winter, it attains almost the same weight when full grown and eats almost the same quantity of food. But the daily consumption of food is greater when the larval stage is shorter than when it is long. The supply or want of food has a direct bearing on the increase of the weight of a larva ; the result obtained by starving one is shown below :—

19-X. 8 A.M. A larva weighed 17·1 grains ; it was kept without food.

20-X. 8 A.M. Its weight was reduced to 14·8 grains ; and it passed only 1 grain of excrements during the 24 hours. At this hour it was supplied 20 grains of green leaves. By 6 P.M. its weight again rose to 17 grains, it ate 12 grains of food and passed 8 grains of excrements.

A single larva of *Ophiusa melicerte* eats more than 60 grains of green leaves, and a single moth lays about 450 eggs. Thus, the offspring of a single moth may destroy about 4 pounds of castor-leaves in about a week and a half.

Damage.—Wood-Mason in September 1887 bred the moth from larvæ attacking castor in Calcutta. (Ind. Mus. Notes, I, p. 56.) In 1888, the pest is reported from Ganjam (loc. cit. I, p. 64), and in January 1889 from "Madras" (loc. cit. I, p. 104). In August 1889, they are reported as injuring castor in Assam (loc. cit. I, p. 199). In July of the same year, the promising eri silk experiment of Mr. Mackenzie in Cachar was ruined by the destruction of the castor plantation by this pest. In 1892, the pest was reported from Dehra Dun and Cuddapah. (Ind. Mus. Notes, III, 3, p. 112.) In August 1900, Dr. Lehmann, Agricultural Chemist, sent the pest to the Indian Museum, where Mr. de Niceville reared it (loc. cit. V, p. 135). In September 1903, it was found attacking castor in Surat, and in 1905 in Pusa, and in the Shripur farm. The Dharwar Farm Superintendent reported

it in that year, and Dr. Lehmann, Agricultural Chemist, Mysore, reported it from Tumkur, Mysore, in August 1905. In June 1907, the small castor crop grown for silk in Pusa was attacked somewhat seriously.

These very scanty records show that the pest is of sporadic occurrence; it is, of course, of far more frequent occurrence as a pest than these records show, as not one in twenty cases of insect injury to crops in India are actually reported correctly or at all. It is apparently one of the common and widespread indigenous insects of India which on occasion becomes abundant and injures the young crop specially by wholly defoliating the plants.

Enemies and Checks.—This widespread insect offers the usual problem to the speculative entomologist; why does it alone of its forty brethren become abundant; what produces the occasional immense multiplication when damage is done? Given an unlimited and perennial food supply, a fairly moist warm climate, and an entire absence of enemies, the multiplication of this insect would be in a geometrical ratio of which something near to 200 would be the multiplying factor. Against this we have some known, and a good number probably of very slightly known factors. There is first the influence of climate; as pointed out above, there is probably a considerable wastage due to irregular development and due to the disappearance of such as do not hit off the hibernating stage; there is another wastage in those which do not hit off the right time to emerge after hibernation; it is a well established fact in Pusa that a few mild, moist days in January bring out a number of moths not usually seen till March; equally, a period of warm, moist weather in March or April brings out many insects not usually seen until the end of May or the first monsoon rains; what happens to these? It is not certain, but they cannot go back into the cocoon, they apparently cannot live indefinitely without food, and they run great risks from various causes by having to live as moths for some weeks longer than usual. Further, their chances of getting mates are very much smaller, and without this they perish in due time.

Another check is an insufficient amount of food ; in some parts of India, castor grows practically all the year, and *dudhi* is an abundant weed in the rains and after. But there are variations in the area of castor planted or in the area of uncultivated land free to grow *dudhi*, and there is in some seasons a greater difficulty for the moth to find food-plants to lay on. The more she has to search, the more risks she runs from enemies, and it is probable that some of the variation in number is due to this cause. The next check is enemies. These are of three classes ; enemies of the moth, of the hibernating pupa, and of the active larva. Of the first nothing is yet known, and it will probably be found that birds are the most important check at this stage. Of the second, nothing definite is known ; it is generally believed that a hibernating insect on the soil is likely to be the prey of very many insects, since there is an abundant fauna of surface insects which are predaceous ; there is every probability that some proportion die during this time ; and to the dangers of this period must be added the danger of accident due to man's agricultural practice ; when one looks over the barren landscape where no insect life would seem to be, one wonders where are all the insects that will appear when rain falls ; where do they hide, where are they ? A great number, including this species, are on the soil, at the edge of a field, in a hedge, in a head-land, among fallen leaves, in any nook and crack that offers shelter ; there is probably no more certain thing, and none more difficult of actual proof, than that clean culture, good tilth, and thorough cleaning of land do more to check such pests than anything else. Every field entomologist who attempts to account for his pests at every season of the year feels this, and above all, when one surveys the level, arid stretch of fields on a hot day in May in India. (Accurate data on this point are being obtained at Pusa, but it is at present impossible to apply these to an individual insect).

A most important check is the parasite figured on Plate VII, Fig. 7. After the attack on the castor in June 1907, it was expected that another brood would appear in July ; it did, but almost every larva died ; the larvæ are found clinging to the leaf ;

the parasite grub comes out of the body and prepares a cocoon ; on this the caterpillar remains fixed as shown in the figure, Plate VII, Fig. 6 ; in July-August many caterpillars could be seen fixed in this manner over the cocoon and the expected big attack never developed. This instance has been a very striking one, because the percentage of larvæ parasitised has been over 80 per cent., and it is clear that, given no hyperparasite, and these parasites hatching freely, the following brood of this insect will be very heavily checked.

The only other one at present known is a Tachinid fly, the larva of which lives in the caterpillar, emerging when full grown from the pupa. This is, of course, a direct check ; in the only instance of which we have a record, only eight per cent. of the larvæ were parasitised, but experience of other species and the high percentage found in some of the larvæ sent in tend to show that this percentage may become a very much higher one. It is extremely doubtful whether the larva has other checks ; no birds have been observed to feed on it ; its scheme of colouring, its gait, its activity give it a peculiarly formidable appearance, but it is not known if it is really warningly coloured or not.

Though we have few accurate data for this insect, we can see that there are factors enough to profoundly influence its increase or decrease. Even if we cannot accurately attribute anything definitely to one or another factor, it is possible to see that there is nothing unnatural in its appearance in hordes suddenly or in the sporadic outbreaks there are from time to time. Until it appears on a crop, we know nothing of it, while it may at any time be abundant on the *dudhi* in the grass without our being in any way aware of it, and should a large number of moths appear together and lay eggs on castor, a sudden and very virulent attack is at once produced.

Treatment.—We are here concerned with the appearance of the pest on castor crops only, and it is to this point that inquiry into the habits of this insect brings us. Is there any possible way of checking the pest or of preventing it from appearing ? When it comes, what can be done ? Looking over the life history, we see that there is no single point that is open to attack ; the eggs, laid singly,

at night, on the backs of the leaves, would not be seen by an expert observer, far less be detected by the agriculturist ; the larvæ are active, are not truly gregarious except when very abundant, and are voracious feeders which complete their life quickly and hide away to pupate ; the pupæ are, in almost all cases, safe in hiding and only extremely thorough cultivation after an attack would destroy them before they turned to moths. The moth is amenable to no possible treatment.

There is, further, the fact of the pest not being always there, but of its coming in one season and then not for a number ; one never knows when it will appear, one cannot follow it throughout the year and take precautions against it at any one season when we expect it to appear. Were it available, heavy spraying with a stomach poison would avail against the larva, and the first young plants attacked would be easily rendered poisonous ; but the method is not available and, if it were, no ryot would see the pest soon enough to adopt a remedy in time. We come to the only other method, collecting by hand, and this is the only suggestion in reach of the cultivator, one which is impractical in a really bad outbreak unless very thoroughly carried out. In a bad attack, a commonsense method such as trenching to isolate the caterpillars would be effective and useful, requiring, however, combination of a kind not often seen in India. In the case of the plantation of castor grown for silk, the free use of a stomach poison is good, but this cannot generally be done as the leaves cannot, of course, be fed to silk worms, for some time to come. The moth is easy to recognise, and comes to light ; if seen and recognised, an attack may be expected ; the complete eradication of *dudhi* by planting waste land in good grass is the most obvious precaution and where castor is an important crop for silk, this would be worth a great deal of care and attention.

The further precaution of dealing with hibernating chrysalides by the most scrupulous cleanliness and thorough cultivation is obvious and in the case of an attack, a good deal can be done by trenching to isolate the pupating larvæ in one piece of ground which can be ploughed over and the pupæ thoroughly eradicated.

In these precautions and remedies, there is no actual means of checking the pest, except handpicking, nor is there any other remedy possible at present. At Pusa the attack on ths castor could be met only by spraying with lead arseniate and this is not a remedy generally applicable nor easily carried out on any scale. On the other hand, the pest is very seldom destructive to castor grown on a large scale. Where castor is grown as a regular crop and there is in every village a large quantity, the insect cannot be really destructive. If castor must be grown on a small scale or in a locality where it is not a staple crop, then the pest may be expected and a trial may be given to handpicking. Above all, the first small brood must be captured, and this may be expected at the end of a spell of cold weather where there is one, or at the time when the dry hot weather gives place to rainy weather. Wherever possible, the greatest possible area should be sown as a safeguard, and if one block can be sown early, and another, say one month later, the earlier sown block will serve as a trap to the insect and the later sown block will be spared.

The pest will affect those who grow castor for silk ; the cultivator in Assam, who does this, sows so little and that so close to his dwelling that he can check the pest quite simply ; but where a few acres are sown, the pest may be anticipated, and if the little that can be done is not done, much injury may be caused. We have discussed this question at some length because pests cannot be checked by rule of thumb methods and the important factor is local conditions ; it is within the power of an entomologist only to give such facts and suggestions as will enable the grower of castor to understand the pest, to know whence and how it comes and what it may be expected to do. He must then put his knowledge to practical account himself.

EXPLANATION OF THE PLATES (VI & VII).

Plate VI.

(1). Eggs on the leaf × 2.
One egg on the right × 8.

(2). Larva in the first stage, one day old × 4.

(3). Larva in the second stage × 3.

(4). Larva in the third stage × 3.

(5). Larva in the fourth stage × 3.

(6). Front of head × 4.

(7). (8) & (9). Larvæ in the fifth stage showing variations in colour (slightly enlarged).

(10). Pupa—dorsal aspect (natural size).

(11). Pupa—ventral aspect (natural size).

Plate VII.

(1). Cocoon underground with adhering earth (natural size).

(2). Cocoon with the leaf, a fold of the leaf being a little turned aside to show the net.

(3). Moth while sitting (natural size).

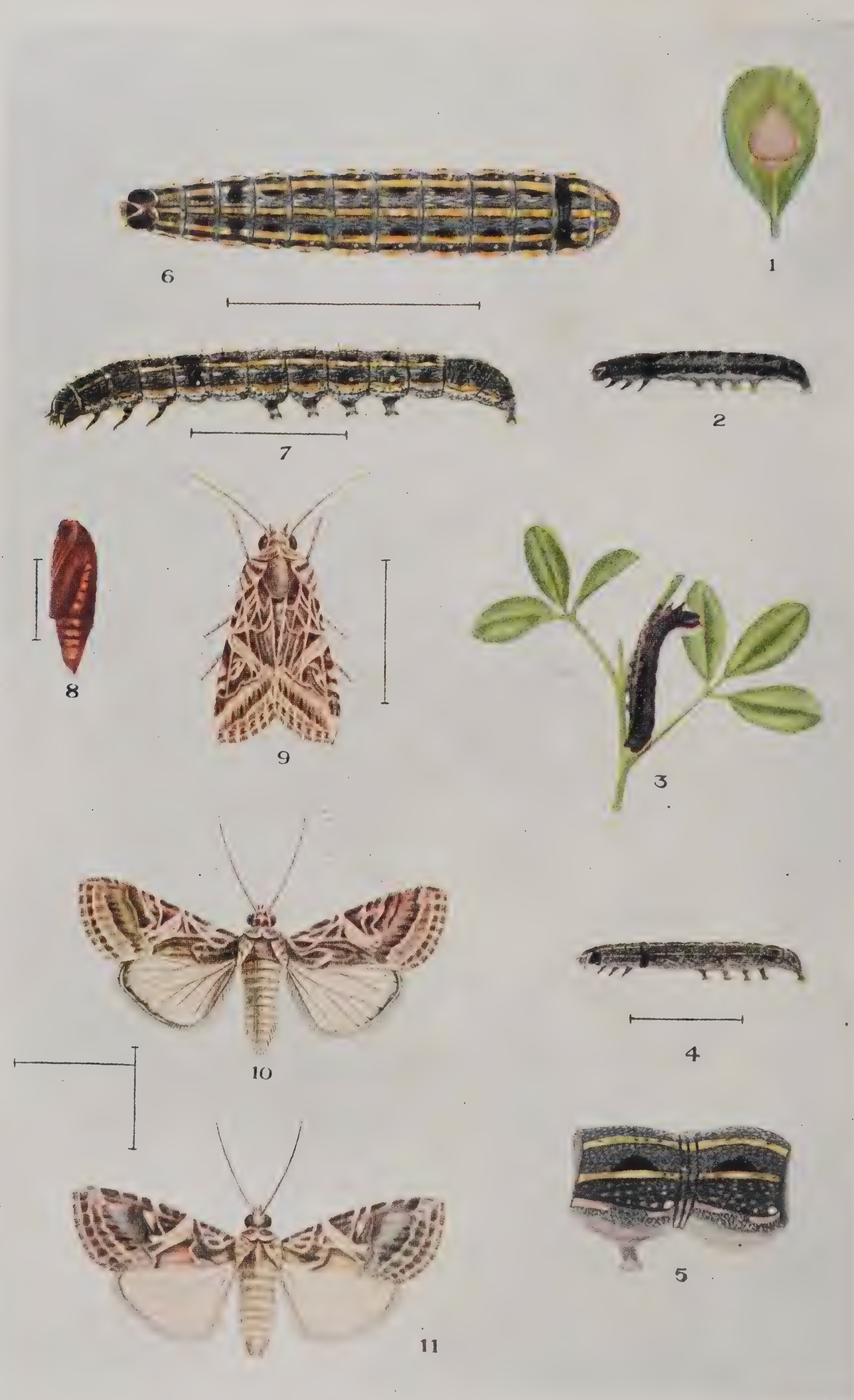
(4). Moth set.

(5). O. algira set.

(6). Dying larva clasping parasite cocoon.

(7). Parasite × 4.

PLATE VIII.



TOBACCO CATERPILLAR.

THE TOBACCO CATERPILLAR (*PRODENIA LITTORALIS*).

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

I.—Description.

The genus *Prodenia* was formerly classed with many others in the Quadrifine division of the family *Noctuidæ*. In the Catalogue of Lepidoptera Phalænæ, its place presumably will be in the sub-family *Acronyctinæ*, with its ally *Spodoptera*, and other destructive insects. In the Fauna of India, Moths, Vol. II, page 247, two species are described; these are *Prodenia littoralis*, Boisd., with a list of six synonyms no longer in use, and *Prodenia minima*, Swinh., described from Hyderabad, Sind, and from no other locality. The former insect is here figured in all stages and we are not aware of any insect in India with which this extremely characteristic moth can be confused. We reprint also the description by Hampson given in the Fauna of India; the genus is characterised by having only light tufts of scales on the abdomen and metathorax, the forelegs smoothly scaled, the male antennæ lightly ciliated. In structure, life history and habits, it is most closely similar to *Spodoptera mauritia*, which is equally a virulently destructive pest.

1829. *Prodenia littoralis*, Boisd., Faun. Ent. Madag., Lep., p. 91, pl. 13, fig. 8; Moore, Lep. Ceyl. III, pl. 146, figs. 1a, b (larva); C. & S. no. 2120.

Pale ochreous, much suffused with dark brown ; abdomen paler. Forewing with some ochreous streaks at base ; an angled and oblique, subbasal line ; a waved and curved antemedial line ; the orbicular oblique, with fuscous centre and black edges ; the reniform an oblique "arrow-head" mark ; the outer half of median nervure and bases of veins 2, 3, 4, and discocellulars prominently pale ; claviform black ; an indistinct lunulate postmedial line excurved beyond cell ; a waved submarginal line with black streaks before it ; cilia with pale streaks through them. Hind wing opalescent and semihyaline white, with dark marginal line. Expanse 30—45 millim.

This description scarcely indicates the very great variability there is, within well-defined limits, in the marking of the forewing. Possibly these variations do not come within the scope of a verbal picture and we have indicated two of the more extreme forms in Plate VIII.

II.—Distribution.

Swinhoe's Catalogue of Eastern Lepidoptera Heterocera gives Borneo, Philippines, Australia, and India as known localities. Hampson, Fauna of India, Moths, gives the Mediterranean sub-region and the Eastern tropics as its range.

In India, it is recorded from localities in all parts of the plains, from the Himalayas and the Nilgiris, and has been reared by all the entomological assistants attached to the Departments of Agriculture. It may be stated to be common throughout India.

III.—Life History.

Eggs.—The moth lays eggs in clusters on the leaves of the food plant, on either side of the leaf, most usually on the upper surface. Each cluster appears as a buff coloured mass, as shown in Plate VIII. This mass consists of eggs laid in close rows, first on the leaf, then on this lowest tier of eggs, and then on the second tier; the whole mass is then covered with buff hairs derived from the anal tuft of the moth. The individual eggs are pearly white when freshly laid ; they are round, and radially ridged from the upper pole,

about half a millimetre across. The size of the clusters varies very greatly ; in smaller clusters there is often only one layer on the leaf ; in the larger clusters there are two or three tiers. Counts of egg clusters show a varying number of eggs from 104 to 450, the majority lying between 250 and 350. A single moth has been found to lay between 400 and 500 eggs. The eggs are, of course, laid during the night. Thus, one moth laid as follows :—

	161	eggs on first night.
	193	,, ,, second ,,
	114	,, ,, third ,,
	30	,, ,, fourth ,,
Total ...	498	

Another laid—

	462	eggs on first night.
	17	,, ,, second ,,
Total ...	479	

The eggs hatch in three to four days in warm weather, in eight days in the colder weather at the end of November in the insectary.

Caterpillar.—The newly hatched caterpillar is about one millimetre ($\frac{1}{25}$ inch) long. It has five pairs of functional prolegs, though it walks with a semi-looper's gait. The colour is dull green, the head black, the prothoracic shield distinct and dark in colour. There are small dark tubercles on the body, with each a slender hair. These larvæ on emergence stay where they hatch in a cluster and feed on the epidermis of the leaf. As they eat, they spread apart a little, but on a large leaf they remain in one company gregariously for the first few days. Like other young caterpillars, when disturbed, they readily drop over the edge of the leaf by a thread of silk and let themselves down by this means.

The first moult takes place after about three days. In the second instar, the length has increased to 2·5 mm. On the first abdominal segment a small dark tubercle appears at each side. There is little change in habits, the larvæ moving out a little, but if there is still food available, they remain eating steadily at the epidermis of the same leaf.

The second moult takes place after three to four days. In the third instar the colouring develops; there is a central longitudinal line of orange or yellow, with a similar dorso-lateral line. On each side of the central line and below the dorso-lateral line is a dark band; this is of grey or black, stippled in white; the lateral dark band has a downward curve in each segment to include the spiracle and meets the lighter colouring of the lower surface in a sharp line, often defined with orange or red. The colouring varies greatly in detail, the intensity of the grey or black in the dark, the amount of white spotting or stippling, the brightness of yellow or orange, all tend to produce larvæ of varying degrees of colour. The general effect is warning. The lower surface, up to the lateral line, is of a dull grey-green, the skin being semi-transparent and practically without pigment. The skin is smooth with short hairs on almost imperceptible tubercles. The striking feature of the larva is the dark swollen band crossing the first abdominal segment, and this is of great value in identifying the larvæ. It is most distinct in this instar, but is well-marked in the next and is then lost.

Another moult takes place in three to four days; the larva now has a length of almost one inch, and the colouring develops completely. It is now active, moving about and feeding on the whole tissues of the leaves, stripping them to the veins. During the day it lies exposed upon the leaf, or, if on a low growing plant, hides on the soil or among the stems. It is most active at night and moves about freely from plant to plant.

After about four days the fourth moult occurs and the larva attains to its full size. It is now a fat caterpillar, the thorax tapering to the small head, the abdomen thick-set and the segments little marked. The transverse band on the first abdominal segment has disappeared; on each segment a black lunulate patch is seen above the lateral yellow line and, in light larvæ, these black lunules are very marked. The larvæ are of varying degrees of darkness and in those that are black, not only do the dark lunules not show, but the lateral yellow line shows only as a series of yellow or orange markings. The colour of the lower surface is a dull grey-

green. This full grown larva grows to a length of 35—10 mm.; it feeds voraciously and is able to do great damage to plants by eating into the soft juicy stems. If food is not available, these larvæ are cannibals and eat their brethren; those killed by arsenical spraying were eaten by any that found them. This habit is not uncommon among Noctuid caterpillars.

After three days of hard feeding, it crawls down off the plant and seeks a place to pupate in. Soft moist soil is what it seeks, and into this it forces its head, pushing the soil aside and gradually burrowing down till it is two inches or more in. Then the particles are drawn together into a compact earthen case in which it pupates. In captivity pupation takes place often with no covering or with particles of paper, etc., drawn together with silk. The pupa is figured in Plate VIII. As no silken cocoon is formed, the abdomen terminates in a straight double spine. Pupation occupies from nine to fourteen days in warm weather.

The imago is nocturnal in habit, remaining motionless by day in some shaded spot. It has been seen at light, but does not appear to be particularly attracted by ordinary lamp light. The males and females are closely similar, the former distinguishable by the finely ciliate antennæ. The colouring of the forewing varies in detail from one specimen to another and the extremes of the variation are very dissimilar.

The whole life history in warm moist weather occupies about one month; a typical record is as follows:—

25th March	... Eggs laid.
28th „	... „ hatched.
31st „	... First moul .
2nd April	... Second moult.
6th „	... Third „
10th „	... Fourth „
14th „	... Fifth „
17th „	... Pupation.
23rd „	... Imago emerges.

Allowing for variations, which occur even in the same batch, about one month in warm weather covers the whole period from egg to egg, since under favourable circumstances the moths couple the first night and the female lays eggs the second.

The following tables show clearly the variation in the duration of periods of larvæ, etc., at different times of the year :—

Larval Stage.

Eggs hatched.	Larvæ pupated between	Duration in days.
26-III	19-IV and 23-IV	24 to 28
22-V	12-VI and 15-VI	21 to 24
30-VI	18-VII and 20-VII	18 to 20
7-XII	19-I and 28-1	43 to 52

Larval moults.

	Hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.	6th moult.	7th moult.
1	26-III	3-IV	9-IV	11-IV	14-IV	17-IV	19-IV	23-IV (pupated)
2	22-V	29-V	31-V	2-VI	4-VI	6-VI	11-VI	15-VI (pupated).
3	22-V	...	...	...	...	9-VI	14-VI (pupated)	
4	30-VI	5-VII	8-VII	10-VII	13-VII	15-VII	19-VII (pupated)	
5	...	...	7-VII	...	...	...	18-VII (pupated)	

Pupal stage.

Pupated.	Emerged.	Duration in days.
24-III	7-IV	14
19-IV	27-IV	8
23-IV	2-V	9
14-VI	22-VI	8
15-VI	23-VI	8
18-VII	25-VII	7
5-X	14-X	9
6-X	16-X	10
1-XI	19-XI	18
8-XI	23-XI	15
8-XI	27-XI	19
22-XI	12-XII	20
19-I	16-II	28
20-I	22-II	33
24-I	25-II	32
27-I	2-III	34

The pupæ are liable to be affected by dryness, more so than most other Lepidopterous pupæ and much like beetle pupæ. A

little dryness in the earth in which they are formed kills them. The following is the result of the submergence of some pupæ in water:—

8 pupated on 24-I.	Eight pupated on 24-I.
Submerged for four hours on 16-II.	Submerged for eight hours on 16-II.
Three moths emerged 24—26-II.	Two moths emerged on 26-II.
Rest spoilt.	Rest spoilt.

Life Cycle.

Eggs laid.	Eggs hatched.	Larvæ pupated.	Moths emerged.	Duration of the cycle.
22-III	26-III	19-IV	27-IV	36 days.
22-III	26-III	21-IV	30-IV	39 ,,
22-III	26-III	24-IV	2-V	41 ,,
19-V	22-V	14-VI	21-VI	33 ,,
19-V	22-V	16-VI	25-VI	37 ,,
27-VI	30-VI	18-VII	24-VII	27 ,,
27-VI	30-VI	20-VII	27-VII	30 ,,
29-XI	7-XII	19-I	16-II	79 ,,
29-XI	7-XII	20-I	22-II	85 ,,
29-XI	7-XII	28-I	2-III	93 ,,
29-XI	7-XII	24-I	26-II	89 ,,

The following tables show the increase in weight of larvæ day by day in the insectary:—

Weights.

100 eggs weigh ·09 grain.

First Larva.

Date.	Weight of larva in grains.	Weight of excrement in grains.	Remarks.
30-VI	......	......	Hatched.
5-VII	......	......	First moult.
6-VII	·32	·2	Weight of excrements up to date.
8-VII	·34	·09	Second moult.
9-VII	·7	·22	
10-VII	·9	·1	Third moult.
11-VII	1·45	·32	
12-VII	2·5	1·2	
13-VII	2·75	·1	Fourth moult.
14-VII	4·48	·7	
15-VII	5·5	·9	Fifth moult.
16-VII	6·0	2·25	
17-VII	4·9	2·3	
18-VII	2·0	*nil.*	Pupated.
19-VII	1·8		Weight of pupa.
20-VII	1·6		
25-VII	1·55		Moth emerged.
	·6		Weight of moth.

Second Larva.

Date.	Weight of larva in grains.	Weight of excrements in grains.	REMARKS.
30-VI			Hatched.
5-VII			First moult.
6-VII	·34	·2	Weight of excrements up to date.
7-VII	·4	·1	
8-VII	·5	·1	Second moult
9-VII	·82	·25	
10-VII	1·76	·4	Third moult.
11-VII	2·0	·02	
12-VII	4·9	1·18	
13-VII	4·5	·9	Fourth moult.
14-VII	7·8	·8	
15-VII	9·4	1·2	Fifth moult.
16-VII	9·65	·8	
17-VII	10·2	1·2	
18-VII	6·8	4·2	
19-VII	2·6	*Nil*	Pupated.
20-VII	2·0		Weight of larva.
25-VII	1·8		
26-VII	·7		Moth emerged; weight of moth.

Third Larva.

Date.	Weight of larva in grains.	REMARKS.
22-V	......	Hatched.
12-VI	8·9	
13-VI 7 A.M.	12·1	
13-VI 6 P.M.	15·6	
14-VI 7 A.M.	13·8	
14-VI 5-30 P.M.	6·8	
15-VI 7 A.M.	4·9	
15-VI 6 P.M.	4·6	Pupated at night.
16-VI 7 A.M.	4·4	
16-VI 6 P.M.	4·35	
17-VI	4·3	
19-VI	4·06	
23-VI	......	Moth emerged.

Fourth Larva.

Date.	Weight of larva in grains.	REMARKS.
22-V	.	Hatched.
12-VI	11·5	
13-VI 7 A.M.	11·9	
13-VI 6 P.M.	5·8	
14-VI 7 A.M.	3·9	
14-VI 6 P.M.	3·3	Pupated at night.
15-VI	3·2	
16-VI	3·2	
19-VI	2·92	
22-VI	...	Moth emerged.

The above four larvæ reached the weight of about 6, 10, 16 and 12 grains respectively. The weights of the larvæ in the fields also vary greatly. The average weight varies between six to ten grains. One larva collected from the field weighed 25·3 grains. The pupa of this larva weighed 4·8 grains and the moth 1·4 grains. As the larvæ are big or small, the moths also vary in size.

It will be seen that the larvæ, like all other Lepidopterous larvæ, reach a maximum weight and then quickly lose weight before pupation. They are not seen to pass a large quantity of excrement, neither do they vomit. If they are kept in a covered dish, they get wet and an appreciable quantity of moisture is found. The water is probably given out in respiration and may account for the diminution in weight.

Hibernation, etc.

The records of the occurrence of this insect, both in Pusa and elsewhere, point to an active season from March to November where there is a cold season, as in all but Southern India. For three seasons, we have seen newly-emerged moths in Pusa in March; in no stage has it been captured or seen in December, January, February except as a pupa; we have larvæ and imagines for every month from March to November. We conclude that the insect normally hibernates as a pupa from December to February; the Pusa dates of first capture are March 15th (1905), 23rd (1906), 30th (1907). (In 1905 an imago was seen but not captured, on 1st March). From April onwards there are records of this insect on various plants through the hot weather and rains to November. With so omnivorous a pest, no definite broods are traceable; it is impossible to actually follow the pest through the year, but it is constantly found on a variety of plants. There is usually one very distinct brood on lucerne in Pusa in April; the next brood of May has been found on Pakur (*Ficus infectoria*), but there are no regular "broods," insects of all stages being found. We should be inclined to give six as the probable number of generations in the year from a pair of moths issuing

in late March *when food is available.* This food must be crops that grow in the hot weather, with or without irrigation, or trees such as the Pakur, or rainy weather crops. Of the last there are abundance, but it is not everywhere that there is green vegetation between March and June. When there is food available, such as irrigated lucerne or vegetable crops, or the leaves of the Pakur tree, then there will be one or two broods prior to the monsoon It is uncertain what occurs in dry localities where there is no vegetation available. The moth does not necessarily mate and lay eggs at once ; they live for over a week in captivity and probably several weeks in the field where food is available.

IV.—Occurrence as a Pest.

In Indian Museum Notes, the insect was reported four times as a pest. It attacked mulberry in Balasore (I, 210, II. 160). It attacked potato in Berhampore (II, 6, 68), cauliflower in Calcutta (V, 131), and the late Mr. de Niceville found it abundantly on indigo in August in Behar (V, 158). The last case is of particular interest as de Niceville regarded it as the second most abundant insect on indigo at that time, *Raparna nebulosa* alone being more abundant ; we may, however, remark that there is a general opinion that caterpillar on indigo, when it is being cut, makes for good produce, so that in this case the insect is not injurious or at least not as yet known to be so. Indian Museum Notes also records it from Sumatra as injuring tobacco (III, 5, p. 59) The most important account of this insect occurs in the Yearbook of the Khedivial Agricultural Society for 1905, under the heading, "The Egyptian Cotton Worm" by F. C. Willcocks, Entomologist to the Society. From this we learn that this insect is in Egypt a serious pest of cotton, in some years causing a loss of 50 per cent. in some parts of Egypt. This loss is occasioned by the caterpillar destroying the foliage. Mr. Willcocks gives a list of fifteen plants fed on by this pest including several of its food plants in this country. Anyone not conversant with the pests of cotton in India would, on the analogy of Egypt, expect this

insect to attack cotton here also. Mr. Willcocks gives Egyptian, Sea Island and Upland cotton as the varieties attacked ; these are, of course, not the commonly grown varieties here ; but it is interesting to note that, out of all larvæ reared from crop plants in India, only one instance has been found of its attacking this plant. (We may point out that this applies equally to the American bollworm of cotton (*Chloridea obsoleta*, Fabr.), which has only twice been observed in India feeding on cotton, though it is abundant upon other food plants). Mr. Willcocks enumerates various parasites and enemies ; his most interesting observation relates to a bacterial disease, and it is to be hoped that this will receive further attention. The remedies applied in Egypt do not at present apply in this country since cotton is not attacked.

This insect has only four times been reported as injurious during the past four seasons, and this number of cases cannot be any measure of the injury caused by it ; but, as will be seen later, it is a specific pest of no special crop in India and its sporadic occurrence is not reported. In October 1903 and 1904 it was reported from Nadiad as injuring tobacco, the larvæ being found on the leaves, which are rendered useless for curing. In May 1906, it was reared from larvæ sent in as injurious to young cotton plants in the Gujrat District, Punjab, with *Euxoa spinifera*. A typical case was reported from Daltonganj, Palamau, in July 1905 by the Deputy Commissioner. This was investigated by C. S. Misra, First Assistant to the Imperial Entomologist. In this case, the caterpillars were so abundant that they cleared the fields belonging to eleven villages ; the crops growing were rice, marua (*Eleusine coracana*), lobia (*Vigna catjang*), maize ; the larvæ were in swarms eating from field to field and devouring the grass between ; the swarms were composed not of this caterpillar only but of other species which were in smaller number ; thus *Junonia almana*, *Parnara* (*Chapra*) *mathias* and *Spodoptera mauritia*, were found with them. On what crop or wild plant this originated could not be ascertained, as by the time the locality was reached, the caterpillars were moving.

A second typical case occurred at Pusa in 1907. An acre of castor, about four feet high, was growing in June for feeding Eri silkworms: egg masses were noticed on it on June 6th; June 3rd and 4th were warm, still days, following a fall of 1·75 inches of rain, and as the egg clusters hatched on the 7th, the egg masses were laid on those nights. On the 6th, 2,534 egg clusters were collected; the clusters gave from 200 to 450 caterpillars each, and taking 300 as the average number, we get three-quarters of a million eggs (three lakhs and seventy-five thousand). From the 9th again on three nights eggs were laid and these were allowed to hatch to give material for insecticide experiments. No estimate of their number could be formed, but the number probably was considerably smaller than those removed. Two insecticides were tried, one an experimental one, the other Lead Arseniate; the part sprayed with the latter escaped injury, while the part sprayed with the former was severely eaten. Further, the caterpillars from the arsenic sprayed portion wandered into neighbouring experimental jute plots where they ate into the succulent top shoot, doing great damage. Handpicking and trenching stopped this injury.

This case illustrates the habits of this pest extremely well; a large number of moths hatched out on these warm, still nights and laid eggs; they laid eggs on the castor presumably because, excepting jute and maize, no other crops were available; not one egg cluster was found elsewhere than in the castor, and neither the jute nor the maize was attacked except by wandering caterpillars from the arsenic sprayed plot. The same occurred at Daltonganj and probably occurs constantly in India, only it is not reported. In such cases the pest, if food is not sufficient, behaves as a swarming caterpillar and moves from field to field, seeking food.

In other cases, the egg masses are more widely spread and the caterpillars do not form into masses and move about. Such are the attacks on tobacco; in this case the larvæ feed normally where they hatch and only spread on becoming half-grown. As stray moths frequently lay their eggs on this plant, a considerable amount of injury is done. We have seen it in considerable abundance in one locality in Tinnevelly, nearly every plant being

infested. In other cases, as with the cotton in Gujrat and the potato in Berhampore, the caterpillar behaves as a surface caterpillar, cutting off young plants at the surface of the soil. Its principal importance is as a pest of tobacco, and observations show that on this crop it is far more common than is reported.

A curious feature of its attacks is its readiness to bore into such soft tissues as the young castor stems or the soft jute stems. Far more damage is done in this way than by mere defoliation since the whole growing shoot is killed. The following is a complete list of the food plants of this insect in India known at present :—

Cabbage.—The caterpillars eat the leaves. A common pest of this plant and cauliflower, etc., important in market gardens.

Lucerne (*Medicago sativa*).—On irrigated lucerne in April abundantly.

Castor (*Ricinus communis*).—Feeding on the leaves and boring into the succulent young stems.

Rice.—A food plant only when in swarms and nothing else is available. Not a specific pest of rice.

Maize.—The same applies to this plant.

Jute (*Corchorus capsularis* and *C. olitorius*).—This is a common alternative food plant, the succulent apical shoot especially being eaten off.

Tobacco.—A serious pest to this valuable crop, eating the leaves.

Indigo.—On indigo in August and later in the rains. Not yet known to be destructive to this crop.

Potato.—Cutting young plants off.

Mulberry.—Eats the leaves.

Pakur (*Ficus infectoria*).—Eats the leaves.

Groundnut (*Arachis hypogea*).—Eats the leaves.

Sweet Potato (*Ipomœa batatas*).—Eats the leaves.

Marua (*Eleusine coracana*).—Only once found.

Urid (*Phaseolus radiatus*).—Occasionally.

Wheat (*Triticum sativum*).—A very unusual food plant.

Tur (*Cajanus indicus*).—Feeds on the leaves and pods.

Sugarcane (*Saccharum officinarum*).—Rarely on the leaves.

Coleus.—Occasionally in gardens.

Agathi (*Seshania aegyptiaca*).—Eats the leaves.

Dhaincha (*Seshania aculeata*).—Eats the leaves.

On the whole, this insect may be written down as a serious and general pest to tobacco in India, as well as an occasional and serious pest to any crops on which it occurs sufficiently abundantly. Unlike specific crop pests, it attacks a variety of crops sporadically and is one of the general pests found in all agricultural tracts.

V.—Enemies.

As with other Noctuid larvæ, parasites are of common occurrence in this insect.

Egg parasite.—A tiny parasitic Hymenopteron has been reared from the eggs but not in great number, and it appears to be of little importance as a check.

Larval Parasites.—A parasitic fly (*Tachinidæ*) has been reared from these larvæ commonly. It appears to be an important agent in checking this insect, and after a big brood, the next brood is heavily parasitised.

The full-grown larvæ are also eaten by birds, especially when about to pupate. Crows, mynahs and hoopoes eat the larvæ when on the ground. When the larvæ were plentiful on castor, it was noticed that birds did not come there and eat the larvæ until they were crawling along the ground; when arsenic was sprayed on and the larvæ fell off the plants and crawled about before dying, these birds came plentifully and fed : so also when the larvæ were crawling about, looking for good spots to pupate in, the birds eat them, the hoopoes even digging out the pupæ as they do worms.

VI.—Treatment.

With the diversity of agricultural conditions in India and seeing that the pest is not a definite specific pest of any one crop, it is impossible to lay down any general lines of treatment. Successful treatment must depend upon the cultivator having a

knowledge of this pest and being able above all to recognise the egg masses. The egg masses are easy to see if already known, and, for three days after hatching, the larvæ can be collected by simply removing the leaf they are on. Were it possible to make the cultivator familiar with this pest, he could, and probably would, remove it in this way. After this no treatment can be advised that is within his reach. Where spraying is possible, Lead arseniate sprayed on is a certain cure. When the caterpillar is so abundant that it moves in swarms, digging trenches to isolate it is a sound method, and if these trenches can be filled with water and then a little kerosene poured over to make a surface film, not one caterpillar can get across. As a rule, the caterpillar over half-grown, does not mind plain water since it floats. If water and kerosene is available, then a trench of the pattern shown with sloping sides is the simplest.

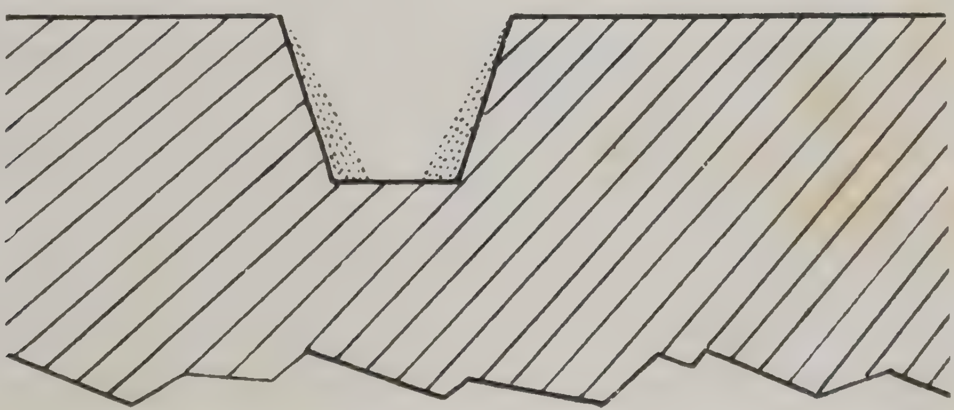


FIG. 1.—Diagram (Cross Section) of Trench to stop marching Caterpillars. Loose earth at the sides is represented by dots.

In the case of tobacco cultivation, nothing but watchfulness and immediate destruction of the egg masses or young larvæ is of any avail. Here, again, a knowledge of the appearance of the pest in all stages is all-important; it is not uncommon to see moths at light, and if the moths are abundant enough to come to light, egg-laying on tobacco may be expected if this plant is growing.

PLATE IX.

COTTON LEAF ROLLER.

THE COTTON LEAF-ROLLER (*SYLEPTA DEROGATA*, FABR.).

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

I.—Description.

The genus *Sylepta* is by Hampson placed in the Pyraustine sub-family of the *Pyralidæ*. It contains 41 Indian species, of which 5 occur widely in the cultivated areas of India ; the life histories of only a small number are even slightly known, these being leaf-rollers in the larval stage. With the exception of this species and *S. lunalis*, Guen., which feeds on the grapevine, none are definitely known as injurious insects in India.

The moth is, in appearance, easily recognised and is not likely to be confused with any common Indian forms. The most important synonym for the Indian student is *S.* (Synclera) *multilinealis*, Guen., by which name it was known until Hampson identified it with *S. derogata*, Fabr. (Journ. Bo. Nat. Hist. Soc., Vol. XV, p. 217, publ. October, 1903). The following description is from Hampson's Fauna of India, Vol. IV, p. 334 :—

"Yellowish white ; the head and thorax spotted with black and brown ; abdomen with segmental brown rings ; a pair of black spots on dorsal band on 2nd segment and one or two black spots towards extremity Forewing with two

sub-basal series of black-brown spots, often developed into lines; an oblique antemedial line: an annulus in cell and smaller one below it; a large reniform discocellular mark; a postmedial sinuous line, highly bent outwards between veins 5 and 2, and usually with a line across its sinus; the veins of outer area streaked with brown; a minutely dentate submarginal line slightly angled on vein 2; a marginal line. Hindwing with discocellular annulus touching an oblique, minutely dentate antemedial line; a sinuous postmedial line, highly excurved and dentate between veins 5 and 2, its sinus crossed by a dentate line; a minutely dentate submarginal line bent outwards to anal angle; a marginal line.

"The Sikkim race has the markings very dark.

"Expanse: 28—40 millim."

II.—Distribution.

Hampson gives the following distribution:—Malayan and Australian regions, East Siberia, Japan, China, West Africa, India, Burmah, Ceylon. Vosseler records it in German East Africa (Der Pflanzer, 1905, p. 360). Zehntner records it from Java as an enemy of cotton: (De Cultuurgids, 1905, pp. 26—31). In India, the Indian Museum have specimens from Sikkim, the Dudgeon Collection from Bhotan, showing that it occurs in the hills. We have specimens from almost every cotton growing tract in India except the Canal Colonies of the Punjab; it is almost universal through the plains of India; we have it from Chittagong, but we are not aware of any other record of its occurrence in Burmah as a pest. It may be said to be probably universal in India except in the Punjab Canal Colonies and may spread into this area in time.

III.—Life History.

In following the life history of this insect through the year, we find that there are two distinct classes of life-cycle:

the single "hibernation" life-cycle which takes place when active life is impossible, and the several active life-cycles, which are, as a rule, passed wholly on the plant. These differ principally in the periods of one stage, and for a description of the life-cycle we may take an active one, as it occurs during the growth of the food plant.

The Egg.—This is typical of the group, a scale-like flat egg, of slightly oval outline, less than one millimetre in diameter. The colour is a pale yellow, the surface almost smooth. Eggs are to be found with difficulty, since they approximate very closely to the appearance of any little mark or splash on the leaf and are only very slightly distinct in colour. They are laid, at night, singly on the leaves or shoots of the food plant; in the field nearly all are found on the lower surface of the leaf, usually of a fairly large young leaf towards the apex of the shoot, less often on the small leaves at the apex or on the coarse older leaves.

It is not quite clear why they should be laid on the lower surface unless it is the instinct of the moth to keep below the leaves even in the dusk and at night; the resting attitude of the moth by day is usually on the lower surface of a leaf with the body horizontal or hanging down; but the moth can rest equally well on the upper surface of the leaf and does do so. In captivity in the insectary, C. C. Ghosh found that of 454 eggs laid by two moths on a growing cotton plant, 344 were on the lower surfaces of the leaves, 106 on the upper surface and four on the stem; that is, three quarters were laid on the lower surface. The conditions were wholly abnormal, however, since the moths were put on the cotton plant for definite periods and not continuously; the following table shows how the eggs were laid in regard to dates and times; the hours given are those during which the moths were set free on a cotton plant in a cage, the intervening periods being spent in a glass dish where no eggs were laid. It will be noticed that the moths laid eggs by day also and, in the shaded light of a cage, this is not surprising.

	Date and time of oviposition.	Number of eggs on upper surfaces of leaves.	Number of eggs on under surfaces of leaves.	Number of eggs on stem.	Total number of eggs.
The first and the second moths together.	18-VIII—6 P.M. to 19-VIII—8 A.M. ...	3	12	......	15
	19-VIII—6 P.M. to 20-VIII—8 A.M. ...	5	15	......	20
	20-VIII—6 P.M. to 21-VIII—8 A.M. ...	7	10	......	17
	21-VIII—5 P.M. to 22-VIII—8 A.M. ...	16	35	2	53
	22-VIII—11 A.M. to 4 P.M. ...	2	15	1	18
	22-VIII—6 P.M. to 23-VIII—6 A.M. ...	25	15	1	41
First moth.	23-VIII—6 A.M. to 24-VIII—10 A.M. ...	31	79	......	110
The second moth.	23-VIII—6 A.M. to 24-VIII—10 A.M. ...	9	62	......	71
	24-VIII—6 P.M. to 25-VIII—6 P.M. ...	8	101	......	109
	Total number of eggs ...	106	344	4	454

The duration of the egg-stage is shown in the following table :—

Eggs laid.	Eggs hatched.	Duration of the egg-stage in days.
18 VIII (night) ...	21-VIII (morning) ...	$2\frac{1}{2}$
20-VIII	23-VIII	3
21-VIII (night) ...	24-VIII (night)	3
22-VIII (11 A.M. to 4 P.M.)	25-VIII (night) ...	$3\frac{1}{2}$
23-VIII (night) ...	26 VIII (night) ...	3
24-VIII (night) ..	27-VIII (afternoon) ...	$2\frac{1}{2}$

Larva.—The larva emerges by biting a hole through the thin egg shell, by which it escapes, leaving the white empty shell on the leaf. The latter is not eaten.

The larva on first emerging measures $1\frac{1}{2}$ mm. in length ; the head is slightly larger in diameter than the prothorax and the body tapers gradually back to the hind end. The head is a dull yellow, the body semi-transparent, of a greenish-yellow tinge. Five pairs of prolegs are fully developed and remain so throughout

larval life. Little change in appearance takes place up to the third moult, the length after the first being 4 mm., after the second 7 mm. The prothoracic shield is not formed; the presence of food in the alimentary canal gives the body a green tinge, absent when the gut is empty. After the third moult, the length is 10 mm., and the partly-divided prothoracic shield is visible. The increasing amount of muscular and fatty tissue between the integument and gut gives the insect a more permanent greenish tinge. At the 4th moult the length increases to 13 mm., and during this (the fifth) instar to 15 mm. At the 5th moult, the length is 18 mm., and during this, the last, larval instar it grows to a length of 25—30 mm.

In this full-grown condition, the prothoracic shield is fully divided and of a paler colour; the head is slightly flattened, the V-shaped suture on the vertex prominent, the ocelli set in a crescent. The transparency of the integument permits the tracheal branches to be seen; the mid-dorsal line is a deeper green, the body generally almost grey. The short hairs are set on minute oval brown tubercles; the spiracles are oval, yellow with a brown rim.

Larval habits.—The young larvæ spend the first few days on the back of the leaf on which they hatch, feeding on the epidermis. After the first moult, when they are from three to five days old, they roll the leaf and live inside this rolled part; this is done by cutting across the leaf near the base and turning the angle thus formed over by means of the contraction of silk threads; at first this roll is small and only takes in a small part of the breadth of the leaf, but by increasing the cross cut and drawing more and more threads across, the roll increases in length and in the number of complete whorls composing it; it is not a cylindrical roll but trumpet shaped, with the wider end towards the apex of the leaf; the later cross threads stretch across the interior of the roll, and it is usual to find the larval excrement entangled in them. The food now consists of portions of the leaf outside of or at the margins of the roll. It is usual to find several young larvæ in one small roll, but these scatter and the larger rolls are each the work of one larva, though there may be

newly hatched or young ones in such rolls as well. On disturbing the larva in its habitation, it leaps actively about and comes out at the wide lower opening to fall to the ground. It appears then to be unable to find its own domicile and, ascending the plant, prepares another. A full-sized leaf-roll occupies practically the whole of the leaf of an ordinary cotton plant.

The following tables show the dates of the larval moults and the increase in larval weight for larvæ during the active growing season:—

Hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.	6th moult.	Duration of larval stage in days.
26-VIII.	30-VIII.	1-IX.	3-IX.	5-IX.	8-IX.	14 IX.	19.
27-VIII.	,,	,,	,,	,,	,,	15-IX.	19.
28-VIII.	,,	,,	2-IX.	,,	9-IX.	,,	18.

Date.	First Larva.		Second Larva.		Remarks.
	Weight of the larva in grains.	Weight of the excrements in grains.	Weight of the larva in grains.	Weight of the excrements in grains.	
26-VIII.					Both hatched.
30-VIII.					First moult of both.
1-IX.					Second moult of both.
3-IX.	·16	·2 (from 26-VIII).	·15	·15 (from 26-VIII).	Third moult of both.
4-IX.	·22	·12	·2	·1	
5-IX.	·3	·1	·23	·06	Fourth moult of both.
6-IX.	·45	·28	·3	·2	
7-IX.	·5	·2	·5	·25	
8-IX.	·6	·1	·8	·2	Fifth moult of both.
9-IX.	1·0	·5	1·4	·7	
10-IX.	1·2	·6	1·6	2·0	
11-IX.	1·3	·6	1·75	1·7	
12-IX.	1·5	1·6	1·3	1·4	
13-IX.	1·6	1·3	1·0	nil.	
14-IX.	1·2	·6			Second larva pupated.
15-IX.					First larva pupated.

The weight of pupa is about 1 grain and that of the moth about ·45 grain.

The Pupa.—The full-grown larva pupates in the roll among the cross threads which traverse its habitation, no definite cocoon being formed ; or it descends to the soil and pupates among a few leaves spun together or in an irregular covering of some such kind. There is a curious change of colour just before pupation, the greenish tinge giving place to a pinkish suffusion. The pupa

has few peculiarities worth note ; the spiracles are oval, with raised rims, which makes them prominent and the third is larger than the remainder. The abdomen terminates in a black process, bearing eight straight spines with curved ends. Pupation normally occupies about seven to nine days.

The Moth.—The moth emerges from the anterior end of the pupa case ; it is nocturnal in habit, flying among the bushes as dusk comes on ; the light colour renders it moderately conspicuous and it sits by day below the leaf with its wings spread out and its antennæ pressed against its dorsal surface. No obvious advantage or benefit would appear to be attached to the beautiful markings of the moth and we have been unable to ascribe any function to them.

The table below shows the duration of the complete life-cycle of a number in the active season ; the whole period varies from $3\frac{1}{2}$ to $4\frac{1}{2}$ weeks and, as an average, we may take four weeks as being the time occupied by a generation. Moths couple (in opposition) on their first night of life, and egg-laying is then spread over several days, so that from the time one egg is laid till the eggs of the next brood are laid is about 30 to 31 days normally.

Eggs laid.	Eggs hatched.	Larvæ pupated.	Moths emerged.	Duration in days.
19-VIII	21-VIII	6-IX	13-IX	25
21-VIII	24-VIII	9-IX	17-IX	27
22-VIII	25-VIII	10-IX	18-IX	27
23-VIII	26-VIII	8-IX	15-IX	23
23-VIII	26-VIII	11-IX	17-IX	25
24-VIII	27-VIII	15-IX	24-IX	31
24-VIII	27-VIII	17-IX	26-IX	33

IV.—Hibernation.

We have hitherto discussed the life of this insect when there was no pause due to adverse climatic conditions ; the eggs hatched, the larvæ fed and pupated, moths emerged to couple and lay eggs again. So long as food was abundant, this would continue, given warm, moist weather such as prevails in the plains of India during the rainy months. In a large part of India, however, it is found that the cold of January and February is sufficient to cause a cessation of the life activities of this species and hibernation sets

in. Hibernation is passed in the larval stage, full-grown larvæ, ready to pupate, alone living through the cold season.

As the weather cools in October—November, the larvæ, as they become full grown, leave the plant and seek a suitable place on the soil ; they just enter the soil, drawing over them fallen leaves or other debris which they web together, and they then spin a rough covering of white silk to which the soil particles adhere. Such hibernating larvæ are to be found at the borders of fields, in little depressions of the surface where fallen leaves gather, in any spot where there is some covering or shelter. Hibernating larvæ are thus found from October onwards, each larva, as it becomes full grown, descending to hibernate thus. Active and living larvæ are found on the plants up to late November or even early December, and exceptionally the middle of December in Behar, since a larva becoming full grown, say on October 10th, might hibernate or might pupate, and in the latter event the moth comes out, lays eggs if a mate is found, and these hatch and behave normally, hibernating when they are full grown ; there is thus a great diminution in the activity of this pest as cold weather comes on, ending in all entering the resting condition gradually. C. C. Ghosh in the Insectary found that no young larvæ could rest, nor could pupæ or moths ; in no stage was hibernation successful but in the full-grown larval stage ; young larvæ feed till they are full grown, or perish of cold ; pupæ emerge after the usual seven to nine days or a little longer, or die ; moths could not be preserved alive. Actually in the field only full-grown larvæ are found during the cold months, and it is certain that hibernation is passed only in this stage.

With the passing of the cold weather and the increasing heat, comes normally a period of intense dry heat ; but, in Lower Bengal, for instance, this is a far moister heat, for, if not accompanied by rain, the atmosphere at least is moist ; in Pusa, either weather may prevail, and it is impossible to make any general statement as to the behaviour of *Sylepta derogata* in regard to the termination of its period of hibernation ; a number certainly emerge as moths in March or whenever the cold gives place to heat ; we believe this number to be much larger when the onset of the warm weather is

moist, *i.e.*, when the percentage humidity in the atmosphere is higher than normal ; we believe this percentage to be lower when the hot weather comes in, as is common, with intense dry heat, the percentage humidity of the atmosphere being very low ; and in the latter case, the majority of moths emerge in May when the humidity grows greater before the break of the rains. It is impossible to get, under normal conditions, accurate observations of the behaviour of a sufficiently large number of insects to deal accurately with this point. Moths are captured as early as March ; young larvæ are found in April and May, breeding on any available plants ; but the greater number of the moths are first caught in May and the larvæ begin to be abundant from July, but are common in June. For Behar the year sums itself up as follows : active succession of broods from June to October ; gradual passing into the hibernating larval condition in October—November, lasting until March or May ; an early brood in April from moths that emerge early but resumption of general breeding only in June.

The following table gives the behaviour in the Insectary of a number of larvæ kept through the winter :—

Date of collection.	How many hibernated.	REMARKS.
30th October ...	3	One moth emerged on 27th March.
31st October ...	3	Two larvæ lived up to 15th June.
2nd November ...	1	
5th November ...	3	One larva lived up to 15th July.
6th November ...	2	
10th November ...	6	Two larvæ lived up to 15th June.
13th November ...	7	One moth emerged on 3rd April. One moth emerged on 13th April. One larva lived up to 5th August.
14th November ...	9	One moth emerged on 18th April. One moth emerged on 4th April. One larva lived up to 30th July, and another up to 27th May.
15th November ...	3	Two larvæ lived up to 15th June.
16th November ...	6	One larva lived up to 15th June.
17th November ...	2	One moth emerged on 20th April. One larva lived up to 15th June.
24th November ...	4	
29th November ...	2	One larva lived up to 30th July.
30th November ...	6	One moth emerged on 29th March. Two larvæ lived up to 27th May.
1st December ...	5	One moth emerged on 25th April. One larva lived up to 15th June.
3rd December ...	5	
4th December ...	7	One moth emerged on 13th April.
15th December ...	4	One moth emerged on 7th April. One moth emerged on 8th April.

The really interesting point is in what stage does the insect normally live through the two or three months' dry, hot weather, when this is very dry as it is in the United Provinces and Punjab ? It is, I think, certain that the emergence of moths in March in Pusa normally coincides with warm, *moist*, still weather, and this equally so in May before the monsoon breaks.

In localities where the hot weather is really dry, with a very low percentage of humidity in the air, the larva does not pupate nor does the moth emerge until the period of increasing air-humidity before the break of the rains ; there is, therefore, a period of "æstivation" or summer rest after the period of "hibernation" or winter rest, occupying about two months and carrying the insect over in its larval stage to May. This æstivation is wholly absent in Lower Bengal, and in similar localities where the intense dry heat does not prevail, where the air in April and May is moist, and where food plants are to be found then. In normal years in Pusa, there is a partial æstivation, *i.e.*, some moths emerge in March, but the majority do not emerge until May.

It is usually possible to a resident in Behar, who closely follows the insect life of the year, to fix the dates of these emergences ; there are the two periods when vast numbers of insects appear for the first time ; their dates vary from year to year and we believe that, according as the early moist, hot period is longer and more moist, so also the greater proportion of each insect emerges then.

We have touched on this point at some length because it is the crucial and difficult point of every insect's behaviour through the year.

An interesting point in the hibernation is the resting larva ; authors state that the pupa is so formed as to give powers of resistance to changes of temperature and moisture ; it would be interesting to know whether a resting larva has a greater power of resistance to such changes, where resistance to extreme cold is not necessary, but where the greater danger is extreme heat and dryness ; in temperate climates there is the extreme cold of winter ; in India it is the extreme dry, parching heat ; and, as in *Sylepta*, this period is very commonly passed by insects as a resting larva

rather than as a pupa. This suggests that a larva, in full growth, has a greater control over the evaporation from the spiracles or from the skin than a pupa in which the tissues have been broken down and reformed, and the resting larva stage so common to tropical insects may be an adaptation to the intense dry heat.

Food Plants.

The food plants are usually those of the order *Malvaceæ;* the common one is cotton, both American and Egyptian, the various deshi cottons, and the native and exotic tree cottons. We are not aware of any cotton that is actually and wholly immune, nor can we say actually that every cotton is attacked; of all those grown at Pusa none could be shown to be immune, but as many grew under very bad circumstances, they might be practically immune when growing well. Bhindi, also called Ramtorai, Lady Fingers, Ochro (*Hibiscus esculentus*), is a constant food plant; *Urina lobata*, under trial as a fibre plant, was infested; the hollyhock (*Althæa rosa*), constantly grown in gardens, is a common food plant; *Hibiscus ficulneus* was also attacked when grown as trial fibre plant. A wild jute (*Corchorus* sp.), grown also in a plot, was found to be a food plant, and this is one instance of the moth having been reared from a plant of another order, this belonging to the *Tiliaceæ*. *Celosia cristata* (*Amarantaceæ*) and *Achyranthes aspera*, both common weeds, are also food plants, the former in Behar, the latter observed by the Entomological Assistant, Ratiram Khamparia, in the Central Provinces. *Malachar capitata*, *Abutilon avicennæ* and *Hibiscus parniformis* were also attacked, the larva in some cases not making a funnel but webbing two leaves together and living between. On the presence or absence of these food plants depends very largely its occurrence through the year; in North India commonly, the moth finds hollyhock in gardens in and near towns during March and April; it finds bhindi, very commonly grown with irrigation, as an early vegetable crop in March, April, May and June; the monsoon brings cotton, bhindi and wild malvaceous food plants such as those mentioned above.

VI.—Destructiveness.

Under normal circumstances, this insect ranks as a minor pest of the ordinary cultivated cottons of India, occurring in small numbers, as a rule, and probably unnoticed by the cultivator in an ordinary year. Occasionally it is abundant enough to check the growth of young plants or to injure the yield of more advanced ones by stripping the leaves. In the cases we have seen, it has been far more destructive to young plants than to older ones ; in the more advanced plants, the caterpillar frequently webs up and kills the top shoot, thus "topping" the plant ; the cultivator frequently believes this to be a good practice and the insect's activities may be a benefit rather than the reverse. It is far more injurious to Dharwar American, the Cawnpore Acclimatised American, and to introduced American cottons generally, as also to the Egyptian cottons. Experimental cultivation of these cottons in different parts of India have suffered severely from this pest, the increase of the insect being in some seasons so large as to lead to the almost total destruction of every leaf on the plants. When these cottons were grown experimentally at Pusa and in Behar generally, they were very heavily attacked each year from July to October, and similar cases are reported from Cawnpore, Baroda and Chittagong. The following extract is of interest :—

> "In 1900, the (cotton) crop was changed to a new field, No. 27, but had the worst insect attack of all the six years, probably to a great extent due to the abnormally wet season. The identification of the insect of this year showed it to be a different one from that of 1895, being *Sylepta multilinealis*, belonging to the Pyralidæ, sub-family Pyraustinæ. Sprayings of tobacco solution, ashes and lime water and of London purple were all tried in 1895, and to no good. The simplest and most effective method has been found to be the one recommended by Mr. Tata as practised in Egypt, *i.e.*, hand-picking and removing all those leaves on which are found eggs or caterpillars. At Cawnpore, September has always been

found the month when insect attack occurs ; and as soon as noticed, the hand-picking is begun and got through briskly ; the cost of this in 1895 and 1899 has been about Rs. 2 to Rs. 3 an acre ; but in 1900, about Rs. 4 an acre. It has been found that if the picking be done early and promptly, little trouble is met with from these insects after the beginning of October. How far the appearance of the cold weather checks the development of the insects or how far the hand-picking itself sufficiently destroys them is a matter on which no positive statement can be made now without more experience. In this connection it may be noted what the writer was informed by a student of the Cawnpore Agricultural School, that at Muzaffarnagar, where the Cawnpore acclimatised Americans were sown by him, the insects appeared in September and were not handpicked, but died in October on the advent of the cold weather, and the writer found no insects on the crop when he visited it about the close of November. (Bulletin No. 15, N.-W. P. and Oudh, by P. V. Subbiah)."

In such cases this pest is one to be very speedily dealt with, or an otherwise promising cultivation is very soon destroyed unless it is done on a very extensive scale. Actually we believe that these cottons are immediately recognised by the moths as being far more desirable than any other food plants, with the result that these plants act as trap plants, drawing to them the whole numbers of this insect within a certain radius ; while there were numbers of larvæ on every plant of American and Egyptian cotton in Pusa, one would find them with difficulty on the indigenous cottons or on bhindi, though the area of these cottons was neither much less nor excessively greater ; generally speaking, American and Egyptian cottons are most infested, then bhindi, then the various indigenous Indian cottons. The fibre plants mentioned above as being under trial were also attacked, but they were in such small area that no comparison is possible. Its significance as a pest lies in this fact, and while it is not one that causes very large annual losses to the country, it is a very serious factor in the cultivation of any but

indigenous cottons, if climatic and other conditions enable it to increase and multiply.

VII.—Checks.

The larva is attacked by a Hymenopterous parasite, which in turn appears to have a hyperparasite. Neither of these insects have been described. The parasite is an important factor in checking the increase of this insect, a large percentage of the brood in September being attacked.

It is not certain what other direct checks there are ; birds have not been observed to destroy the larvæ but may do so ; the moths are very likely the food of bats or of such predators as Mantids. It is likely that, in cultivation, the greatest checks are those due to climate and to the absence of food plants, coupled with the difficulty of obtaining any safe place where the larva can spend the cold weath r or the very hot dry weather.

VIII.—Prevention.

It is evident that any measure that will destroy the resting larvæ between the end of one season and the commencement of the next will be a check on the numbers of this insect during the next year ; ordinarily where a crop of cotton is regularly grown and is in the land for only a definite season, the ploughing of the land after the crop is taken off and before the moths emerge would affect this ; this is not usually possible and it is a common practice to leave the cotton stalks standing until the next rains ; this practice aids the insect also by providing the moths emerging in the hot weather with plants on which to lay eggs and so provides for an early brood. This is not of much importance in the case of the ordinary cottons grown in large areas in India, but it is important when the cotton grown is an acclimatised American or some similar exotic cotton. In all cases where many varieties of cotton are grown which come on irregularly or where the cotton does not have a short season, attention should be paid to this point, and if the cotton can be ploughed out and the whole area well cultivated,

including headlands, at some time when the larvæ are resting, there will probably be less of the pest in the following season. If, also, it can be arranged that there shall be no growing cotton during the season when the moths emerge first, an additional check is put on the increase of this pest.

IX.—Treatment.

As with all pests of this kind, there is but one real treatment, to destroy every rolled leaf with its caterpillars in, as soon as seen, from the beginning of the season. The pest begins in small numbers; few survive the difficulties of the preceding periods of rest and waiting; and, when the very characteristic rolled leaves are seen on the American or Egyptian cotton, they must be immediately removed. It is unnecessary to destroy them, but it is best to put them into a wire gauze covered box or into any closed receptacle and rear such parasites as may emerge from the larvæ.

At Pusa, before this pest was fully known, the crop had become so infested that this measure would have been both drastic to the plant and expensive in practice. The crop was accordingly sprayed with lead arseniate, a certain and easy cure where it is possible. Were any remedy required on large areas of valuable crop, the American and West Indian method of killing their cotton leaf worm would be the best, *viz.*, dusting on lead arseniate or Paris green with or without lime. The question of the propriety or not of growing bhindi depends wholly upon the presence or absence of other food plants; where there is any jungle or waste land, then wild food plants will be abundant and bhindi does no harm; but in well-cultivated areas, the growing of bhindi is a dangerous practice, since it may, and usually does, provide food at a critical time of the year.

Apart from this, it is essential that, for the first few years of the trial of exotic cottons, measures shall be taken promptly to check this pest; that it is possible and easy has been demonstrated at Pusa, where every kind of cotton was grown and where actual damage to the crop occurred only in the first year when measures of any kind could not be carried out.

EXPLANATION OF PLATE IX.

Sylepta Derogata.

(1). Eggs as laid on the leaf × 3.
(2). One leaf rolled up with the larva on it × 2.
(3). Two segments of the larva shown magnified × 8.
(4). Chrysalis—dorsal aspect × 2.
(5) Chrysalis—ventral aspect × 2.
(6). Moth while sitting × 2.
(7). Hibernating larva.
(8). Moth as seen flying.

NOTES ON INDIAN SCALE INSECTS (COCCIDÆ).

By H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,
Imperial Entomologist.

In a recent Memoir (Vol. II, No. 2), Mr. E. E. Green described new Indian species and enumerated 102 species as Indian. Notes on the food plants are given below and the life-cycle of three species is described in some detail. The numbering of the species is that of Mr. Green's list of Indian species.

5. MONOPHLEBUS STEBBINGI, *var.* OCTOCAUDATA (Gr.).

Among the more noticeable insects of Behar, is the large mealy bug found abundantly upon trees in April-May. Owing to its large size, its conspicuous white colour and its habit of clustering upon the terminal shoots of trees, this insect is more familiar than any other of its family. During the past three years, it has been under observation at Pusa, and the details of the peculiar life-history have at length been observed.

The female.—Yearly at some time in the cold weather (December to February), large numbers of the young bugs are found upon shrubs and low plants. These are dull gray-brown insects with a slight mealy covering, measuring about 4 mm. in length ; the body is oval and flattened, the antennæ black, seven jointed (fig. 9*a*.) ; an eye-spot exists a little outwardly of the base of the antenna, the legs are black, long and projecting beyond the sides of the body ; the rostrum is between the bases of the first pair of legs, short. The anal aperture is on the dorsal surface near the hind end.

These are the bugs of the second instar, after the first moult. They cluster upon shrubs and low-growing plants, with the rostral threads firmly fixed in the tissues of the plant ; as a rule, the twigs

are most infested but the stem may be also, and more rarely the leaves. They remain here for some time, apparently feeding, and a considerable quantity of liquid excreta falls, and drying on the leaves, forms the usual sticky deposit in which black blight grows. It has not been possible to ascertain the exact period of this instar; the bugs were found in immense numbers in January in one year, in February in the others; there is no regularity in their moults and some are very much later than the main body; about six weeks covers the period between the emergence of the newly moulted bugs on the bushes and their next moult.

The second moult has been observed to take place in March, rarely as late as April; prior to this moult the bugs nearly all migrate to trees, the majority occurring on figs, but still a large number on shrubs, on fruit trees, or on Sissoo. The moult takes place either on the bark, on the leaf of the bush, or on the end shoots of the tree. The bug is firmly attached by the rostrum and remains for some days motionless; the skin then splits from the middle of the anterior end to about one half of the length down the mid-dorsal line and a short distance down the mid-ventral line (Plate X, fig. 2); the antennæ, legs and rostrum are soon free; the hind end of the body requires a considerable amount of time, but is eventually free; the insect then rests and walks out, leaving the old skin attached to the plant by the rostrum.

In its third instar, the insect is first a reddish colour, which becomes obscured by the mealy covering and also by the darker colour of the integument as this thickens; the antennæ are distinctly eight-jointed (fig. 9c.), the legs longer; the genital aperture on the ventral surface is at first distinctly visible, with smooth yellow lips, but becomes obscured by the mealy covering. The female then walks up the tree and fixes herself to a terminal shoot; the body becomes more densely covered in mealy wax excreted by the dermal glands and a considerable increase of size takes place; before the moult the length is about 7 mm., soon after, when the bug starts to walk, it is 8 mm. The body is flatter, broader and the bug is very evidently thin at first (Plate X, fig. 1). The female is then fertilised, usually from one to three weeks after the general moulting period;

while on the tree a certain increase in bulk has taken place, and she is flatter and more covered with mealy wax ; the newly emerged males have been seen to couple with newly emerged females, both on the same day as they moulted. After fertilisation, she remains fixed to the plant, feeding on the sap, and a further increase in size takes place till she measures up to 18 mm. in length ; the mealy coating is denser, and white, especially thick under the head and forelegs ; the insect very conspicuous on the plant.

During April-May, the bugs become active and walk about on the tree, gradually moving downwards along the main trunk towards the soil. Then they gradually disappear, their numbers get less and less, and before the rains set in in June all are gone. From now until the following December or January, the insect is not seen again. Careful search revealed the fact that when these large bugs descended the tree in April-May, they hid themselves away in sheltered spots on or near the tree ; in the case of a single large pipal tree which was kept under close observation for two years, the bugs were found in masses among the debris collected at the foot of the trunk ; it was found that the bugs slowly moved into hiding into such masses of debris and there laid eggs : egg-laying was observed taking place. (Plate X, fig. 4.)

A large mass of white cottony wax is first formed at the hind end, and in this is laid a mass of small round yellowish red eggs. The female during this process gradually shrinks away and eventually her shrivelled body is found beside the mass of eggs. In the free state, in crevices of the bark and among debris I was unable to find any definite ovisac produced, the eggs being in an irregular and shapeless cocoon of soft white threads. In captivity, the female produces a far more regular ovisac ; the threads poured out first are so numerous that they form a felted mass ; eggs are then laid in this, and as they are pushed out and push away the felted mass, more threads are produced round the eggs so that a fine, very slightly fluted egg mass is produced, the apex of dense cottony matter, the sides lighter. Finally the dried female is left on the egg mass in a dead and shrivelled condition. (Plate X, fig. 3.)

The number of eggs laid varies from about three hundred to four hundred in specimens in captivity. The number is probably in direct ratio to the bodily development and probably the larger individuals in the free state produce more. In some cases, so great was the mass of females that the eggs were literally dug out in handfuls, and in some spots at the foot of the pipal there was a mass of eggs and debris some inches thick.

It was supposed that these eggs might hatch with the rains, but constant observation showed no young ones. In October, a mass of eggs was removed to the Insectary and these hatched on the 27th and 28th November with remarkable unanimity ; at the same time, examination of the pipal showed abundance of the young insects hatching out. The young nymph is at first $1\frac{1}{2}$ mm. long, of the same sordid reddish colour as the larger insects ; the antennæ are six-jointed, the legs distinctly smaller and shorter. The young nymphs feed very largely upon the vegetation near the ground or upon the portions of the tree at the surface of the soil ; apparently their rostral threads can penetrate the bark sufficiently to obtain nutriment, and it is rare to find that they ascend the tree to obtain food ; they are found also upon low vegetation and upon bushes, but during the first instar the majority are hidden

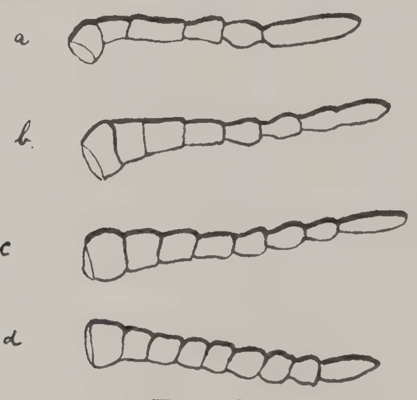


Fig. 9.

(*a*). Antenna of male or female first instar.
(*b*). Of female second instar.
(*c*). Of female third instar.
(*d*). Of male second instar.

among the debris in which they hatched. The duration of this instar is not definitely ascertained but for the main mass appears to be about two months ; cold seems to have no decided effect upon them, since they were active and transformed as rapidly in the cold

winter of 1904-05, and 1905-06, as in the milder one of 1906-07. This completes the history of the female throughout the year.

The male.—Male and female bugs have not been distinguished in the first instar and the account given above of the eggs and first instar applies to both sexes. In the second instar, the bugs, though alike in appearance, are distinct in that the male has nine-jointed antennæ. (Fig. 9*d.*) It behaves exactly as do the females coming up with them to feed in clusters, and being found for about six weeks in February and March. The full grown male bug, however, does not proceed up the tree, but prior to the second moult, when it measures about 7 mm. in length, it hides away and prepares to transform.

Great difficulty was experienced in finding these pupæ but a chance find gave the clue after much search. Pupæ and pupating bugs were found in the hollows of Sissoo trees, as also in sheltered spots in the trunks of pipal and other trees. There are abundant places in the trunks of such large trees where a bug can hide away securely and it is in these inaccessible spots that the male pupæ are found. The nymph moults, leaves the empty skin, and moves away in search of a secure place ; here it fixes itself, and remaining motionless commences to produce cotton from the dermal glands ; a cloud of white gradually forms around it, the bug resting on its extended legs so as to have as much space as possible between itself and the surface of the tree for the cottony covering ; this cottony growth increases and gradually forms a shapeless soft cocoon-like covering ; in this the bug lies and the pupa is found, the wing-pads forming gradually. The pupa is figured ; it measures 4 mm. in length ; the legs, wings and antennæ are visible and lie free outside the body ; the colour is at first a reddish-yellow, deepening as the winged insect forms. (Plate X, fig 5.)

The first males emerged in March, in each year, the pupal period being between three weeks and one month in captivity. The majority hatched out in April and they were then common. The male is a striking insect whether at rest or in flight (Plate X, fig. 6) ; the flight is slow and steady and the male is active by day.

It seeks out the female fixed to the tree and fertilises her in the usual manner of *Coccidæ.* Fertilisation appears to occur every year early in April, the male not being found after that month.

The above summarises the life-history of this insect as it has been observed at Pusa. There are certain points about this which we may draw attention to : the length of the life-history is striking and unusual in Coccidæ ; the long resting period of the eggs is also striking and it would be intersting to know why the life-history is of so peculiar a kind. One fact which must not be lost sight of, is that the trees infested by the bug come into leaf during March-April, so that the bug can find abundance of food at that time in the flow of sap to the tips of the shoots. So large an insect requires much food, and we may hazard the speculation that the life-history is to some extent an adaptation to the habit of the tree. In Pusa, the insect is normally found upon the following species of *Ficus :—*

F. bengalensis, the Banyan.
F. infectoria, the Pakur.
F. religiosa, the Pipal.
F. glomerata, the Gular.

It is also found, especially in the young stages, upon a variety of bushes or low plants, practically upon any bush or plant that happens to be near where the bugs hatch out. The edible fig (*Ficus carica*) is infested and injured ; Sissoo (*Dalbergia sissu*); Mango (*Mangifera indica*) and the Jack (*Artocarpus integrifolia*) are infested ; in 1908, Mango and Jack trees in Tirhoot were very heavily infested and many fruit-bearing shoots withered and dropped off.

Finally, we may emphasize certain practical conclusions. Knowing where the bugs descend to lay eggs, it is not difficult during the rains to clean up the debris and accumulated soil, etc., and destroy the eggs. It is, of course, useless to remove this mass of eggs to a compost heap or manure pit unless it is certain that the eggs are really killed, and we believe this will be secured only by burning. The eggs will stand a great deal of ill-treatment

in the way of removal and casual handling or burying. That this method is effective is shown by the almost complete disappearance of this insect from Pusa, though it is abundant on nearly all its food trees outside. Secondly, it is easy to keep the bugs from ascending a valuable fruit tree, such as a mango ; strips of tin, or, in the cold weather, card-board, bent at an angle and fastened to the tree and painted below with tar, are sufficient. For a short time a band of sticky tar on the bark is sufficient, and the bugs, being unable to cross the tar, cannot ascend and infest the tree.

This mealy bug is the prey of the Coccinellid beetle *Aulis vestita* Muls. The larvæ and beetles are found upon trees infested by the bugs and both may be observed feeding upon them. The larva is figured here ; the colour is a purple red, somewhat obscured by a slight powdering of white. (Plate X, fig. 7.) It walks about the bark of infested trees in a rather sluggish manner ; the bugs are commonly attacked from below and the larva deliberately eats into the body of its victim which appears to make no resistance. Bugs are attacked in all stages, even the very large females being eaten. The full-grown larva pupates upon the bark (Plate X, fig. 8) ; the beetle is sluggish and difficult to find, hiding commonly in cracks in the bark ; it has been observed to eat the bugs just as the larvæ do. During the period that the bugs are active the beetle is found with them, and breeds freely during this time. From the time the bug disappears till it reappears again, only the beetles have been found, and they only in an apparently torpid state hidden in cracks of the trunk of a tree. So far as can be ascertained, the beetle has a similar period of activity to the bug, resting in the intervening months as an imago until the supply of food again enables it to reproduce. (Plate X, fig. 9).

The only other enemies found to occur are two parasitic insects reared from the bugs in April-May. One of these is a dipterous parasite whose larva emerges from the body of the female and pupates in the soil. The other is a very tiny Hymenopterous parasite which is possibly a hyperparasite. Both occur in very small number apparently, as out of a very large number of bugs investigated less than a score were infested.

8. Icerya aegyptiaca (Dougl.).

This species is almost a specific pest of the cultivated crotons *(Codiaeum variegatum)* especially when grown in pots. It is common in many parts of India and is probably widely spread on this plant over India.

10. Icerya minor (Green).

Two complete successive broods of this species were reared on mango in the insectary. The eggs of the first hatched on March 21st and the eggs laid by the adults of this brood hatched on June 26th, one generation occupying 97 days ; the eggs of this second generation hatched on the 16th August, giving a period of 51 days. The third brood failed to reach maturity through constant changes of food plant, and a later brood failed in the cold weather. It would appear likely that allowing for cold weather, there are four broods yearly on mango.

As in all Coccids, the males and females alter at the second moult, the former entering a chrysalis stage prior to emergence as a winged adult, the latter remaining wingless.

The Egg.—The egg is of oval outline, round in section, with rounded ends, about three-quarters of a millimetre long. It is at first white, growing yellow later. (Plate XI, fig. 1.) Eggs are laid below the female in an ovisac formed of white cottony material, secreted by the female ; which forms a pocket below the abdomen. (Plate XI, fig. 11.) The eggs are retained in this ovisac and are carried about ; the ovisac is not visible from above and does not project behind as in other species of *Icerya*.

In the insectary, a total of 57 eggs was laid by the largest female under observation, a smaller one laying only 23 eggs. The precise period during which the eggs remain in the ovisac could not be ascertained but all hatch within two to three days. Before hatching, the egg becomes yellow, with the two dark eye-spots of the nymph clearly visible. The shell splits along the mid-dorsal line, the nymph creeping out.

Nymph.—The newly hatched insect is shown in Plate XI, fig. 2, enlarged twelve times linear, fig. 7, much more enlarged. It is a little less than a millimetre long, flattened and slightly convex above. The six-jointed antennæ are visible in front ; there are fine white hairs on the antennæ, which are long on the apical joint. The legs are long, with fine white hairs ; the one-jointed tarsus has a single claw. The anal cleft has long white backwardly-directed hairs ; from the anal cleft rises a short process, white, brittle and composed apparently of the same waxy material as covers the body of the female insect. This process is tubular, and the liquid excretion passes along, forms a drop at the tip and falls off ; the process is more noticeable in older insects, as seen in Plate XI, fig. 3.

After emerging from the egg, the young insect remains in the ovisac for some hours, and then, passing out between the margin of the ovisac and the mother's body, walks up the plant and fastens itself on the lower surface of the leaf, near the mid-rib. They are gregarious in the sense that many will attach themselves together along one leaf, but presumably the uniformity of their instincts brings them all to one spot. As the nymph grows larger, white waxy patches form on the skin, four large patches on the mid-dorsal line, a series of marginal ones, and fine white points between (Plate XI, fig. 3).

The waxy tube referred to above is more conspicuous now, and, in the insectary, attained a length of five inches. It breaks at a breath of air and is constantly growing. The liquid excretion is found only at the apex of this tube and falls clear of the insect on the leaf, where it dries and forms a medium for the growth of sooty mould *(Capnodium)*. The waxy tube is movable within quite small limits ; it is apparently a device to secure that the liquid excreta shall not soil the nymph, but why it should be developed only in the first-stage nymph is not clear. It is apparently the product of a group of glands round the anus, which secrete the tube and push it outwards, thus making up for the constant breakages. Fig 3 shows the typical appearance of the nymphs with the functional tubes, each magnified four times. The nymph

having settled down, moves only at each moult, unless disturbed ; the rostral threads are firmly embedded in the tissues of the plant, and if a nymph is disturbed, it can be seen to struggle to extract the threads.

At each moult, the skin splits longitudinally on the mid-dorsal line, and the insect crawls out ; the colour is yellow and the white waxy masses commence to form immediately. The moults were as follows :—

Hatched ...	21-III.	
First Moult ..	10 to 12-IV.	
Second Moult ...	24-IV to 5-V.	The male appeared as the imperfect chrysalis.
Third Moult. Winged Males emerged ...	4 to 14-V.	
Females moulted ...	11 to 14-V.	

The females change little at each moult ; after the second, they measure about 3 mm. by 2 mm. ; there are 22 or 23 waxy patches round the body and the dorsal patches are broken up into 16 smaller ones. Their appearance after the third moult is shown in Plate XI, figs. 9, 10 ; they then measure about 3·5 mm. by 2·5 mm., and continue to grow till they measure from 4 to 6 mm., there being great variation in this respect in the individuals of one brood hatched from one set of eggs. The legs remain functional throughout life ; the mature female is shown in Plate XI, fig. 11, magnified five times.

After the second moult, the males develop no wax, are flattened and yellow, with longer legs and antennæ and with larger eye spots ; they gather together in a group, always close to where they moulted, and secrete a cloud of white waxy cotton, which envelops them. (Plate XI, fig. 8.) The legs and antennæ are then folded and the insect's wingpads form on the dorsal surface ; the body shrinks, the segments become more clearly marked and the definite chrysalis form is assumed ; this is shown in Plate XI, figs. 4 and 5. The resting period lasts for about nine days. The insect can move the legs and antennæ to some extent, and if disturbed even moves about a little : at the end of this period of rest,

a very thin pellicle is shed and the fully developed winged male emerges.

The winged male is shown in Plate XI, fig. 6, much magnified. The compound eyes project noticeably from the head ; there are no mouth parts ; the antennæ are 18-jointed ; there are two small processes at the apex of the abdomen, each with a few long hairs ; there is no conspicuous penis as in many male Coccidæ. The wings are connected at the base to the hooked process arising from the side of the metathorax.

From the time of the second moult, the males cease to feed ; they are helpless as pupæ and as adults they live only to fertilise the females. The act of mating could not be observed ; they remained motionless by day and flew about at dusk. In the insectary they lived for three days only.

Males appear about the time the females are undergoing their last moult The following dates show the duration of male and female life :—

Bugs hatched ...	21-III.	26-VI.
Males emerged ...	4 to 14-V.	10-VIII.
Females laid first eggs ...	26-VI.	16-VIII.

This species has been found in small quantity upon mango in Pusa. It is not destructively abundant ; one of the many Coccids normally found upon this fruit-tree.

12. Walkeriana cinerea (Green).

Found rarely upon the babul (*Acacia arabica*) and upon mendhi (*Lawsonia alba*). The first stage nymphs are provided with long hairs, and have been seen to float in the air like thistle down. The life-history of this large and conspicuous insect should be easy to work out and of great interest. We have seen it only in Surat and Western India.

17. Asterolecanium miliaris, Boisd. var *robusta* (Green).

This occurs in enormous numbers on the green stems and on the sheathing leaves of bamboos, especially the giant bamboo (*Dendrocalamus* sp.) at Pusa.

19. Cerococcus hibisci (Green).

This is sometimes abundant upon cotton, occurring in clusters on the shoots. It has been found in South India as well as in Calcutta; in the former case on indigenous cotton, in the latter on tree cotton. The Superintendent, Victoria Gardens, Bombay, sent it in as destructive to *Hibiscus liliflorus* at Pusa; it infested Dharwar-American and Broach-Deshi cotton. It was also sent in from cotton at Myingyan, Burmah, attacking plots of tree cottons. It is not a pest of cotton in the sense that it habitually attacks and injures the plant, but it might well prove to be so were it to spread to a new country. It is heavily parasitised by Hymenoptera

23. Dactylopius Citri (Risso).

We reprint the account of this pest given in Bulletin No. 2, on Insect Pests of Coffee in India, as this is an important enemy to seedling coffee.

(*a*) Mealy bug (*Dactylopius citri*).—This insect is one of the true mealy bugs as distinct from such insects as the Green Mealy Scale. It is at present known to attack coffee in Coorg only and should not be confused with the Green Mealy Scale which attacks shade trees.

Injury to Coffee.—The mealy bug, as a rule, lives in the soil to a depth of three to four inches, feeding on the roots. The insects may be found attached to the main and to the smaller roots, and they occur up to the surface of the ground on the bark. As a result the roots die, the bark of the underground stem and main root is destroyed and the young plant does not grow. The greater part of the damage is caused to the trees under three years old when once established; the bug does little harm. There is nothing to show what is doing the damage unless the soil is cleared away from the roots, when the mealy bug can be found. In rare cases the mealy bug also lives on the stem above the ground, but this occurs chiefly in old coffee bushes.

Food plants.—In Coorg, the mealy bug is also found on the roots of the white weed or goat weed (*Ageratum mexicanum* and *Erythrina lithosperma*). Elsewhere the insect is a common pest of garden plants, croton, lime, orange, etc., as well as many crops.

Remedies.— Two very simple means of dealing with this pest offer themselves and there is no reason why any plants should suffer from the attacks of the mealy bug. The first is the use of lime and sulphur as a dry application; the second, the use of a liquid insecticide such as McDougal's I. and F. wash, or a mixture of tobacco and soap.

(1). Lime and sulphur can be used in several ways. The use of lime and sulphur has been thoroughly tested by A. H. Jackson, Esq., of Pollibetta, Coorg; and it is through his experiments that it is possible to recommend this as a sure remedy, the result of a year's treatment having been examined at Pollibetta.

In the first place, it is necessary to protect the young plants; the soil used for basket plants should be mixed with lime and sulphur, which will deter the bug from attacking the young plants. The proportions used are :—

One basket of	finely	powdered	sulphur.
Four baskets	,,	,,	lime.
Seventy ,,	,,	,,	soil.

It is possible that the proportion of sulphur might be reduced in this mixture, but the above has given satisfactory results. Not only are the young plants protected in the nursery, but, when planted out, the lime and sulphur in the soil protects them as long as it remains. When the original basket soil becomes covered over with ordinary soil, the bugs will attack the crown of the plant where the ordinary soil lies. Lime and sulphur mixed at the rate of four to one can also be placed round the roots and crown of young plants. It is only necessary to bend the young plant over each way and drop in the powder; about one ounce is sufficient for each plant, and the powder should penetrate as far down into the roots as possible. The powder must also be placed up to the surface, as soon as the soil covers the lime and sulphur, the bug is likely to attack the plant at the crown, the lime and sulphur having only a purely local effect.

The results of this treatment, as carried out by Mr. Jackson, are fully satisfactory, and it places a very useful remedy in the hands of the planter.

The cost of lime being Rs. 14 per ton, sulphur Rs. 140, the actual cost of $7\frac{1}{2}$ tons of the mixture the sifting, application, etc., to 270 acres amounted to Rs. 272, being a cost of about Re. 1 per acre for the treatment of a large number of young plants.

(2). Liquid insecticides have a distinct value in cases where the mealy bug already infests young plants. Infested plants watered with liquid insecticides become temporarily free of bug; the effect will not last more than a week or so, especially invery wet weather, but many mealy bugs can be destroyed in this way, and this treatment, if supplemented with a dose of lime and sulphur, is effective on young plants infested with the bug; only such insecticides can be used as will not injure the roots of young plants; this practically limits them to two: McDougal's I. and F. wash, and tobacco and soap wash.

The first may be dissolved at the rate of one gallon to 100 gallons of water; the second is made thus: dissolve 12 lbs. hard soap in hot water, soak 24 lbs. tobacco in 24 gallons cold water for one day, mix the two and make up to 100 gallons with cold water.

These liquids may be poured down the roots of the young plants, about one-sixth of a pint being sufficient for each plant.

The above two methods are the simplest and most effective direct methods of checking the bug. There are two other recommendations of general value :

(3). Destroy *Erythrina lithosperma* and check the growth of weeds as much as possible. The white weed is a favourite food plant of the bug as also is the *Erythrína*, and it is useless to encourage the mealy bug, by giving it its favourite food plants.

(4). A heavy dressing of lime and sulphur (8 to 1) may be applied to badly infested land. At least ten cwts. should be applied per acre, costing about Rs. 15 per acre. This will discourage the mealy bug on the white weed and greatly assist in checking the spread and increase in badly infested land.

(5). Pay great attention to maintaining the vigour of the coffee. This applies to *all* cases of scale insect attack and is further discussed on page 16.

There is reason to believe that this species also habitually infests the roots of Sandal (*Santalum album*) and it has been suggested that it has some connection with psike disease of this plant.

25. Dactylopius Nipæ (Mask.).

This insect is one of the causes of the deterioration of seed potatoes in the plains and is of general occurrence in Bengal and Eastern Bengal. The bugs cluster at the eyes, and apparently suck them out ; the figure on Plate XII illustrates a typical seed potato so infested. On cotton, this insect causes gall-like swellings of the terminal shoots, especially of the indigenous Broach cottons when grown in Behar ; the shoots swell, twist and form a hard apical knot, on which the bugs live ; growth ceases and the plants become very seriously affected. The cultivated garden Hibiscus is infested and becomes twisted just as cotton does. When the insects are abundant, they are the prey of the caterpillar of a small undescribed species of *Eublemma*, which may be reared in numbers from the colonies ; they are also preyed upon by the white tufted larvæ of *Scymnus nobilis*, Muls. and *S. xerampelinus*, Muls., and are the food of the small *Lygaeid*, *Geocoris tricolor ;* a fly grub feeds upon the eggs under the mother bug, and a Hemerobiid has been found to feed upon the bugs.

27. Dactylopius Saccharifolii (Green).

This insect was first found upon sugarcane growing in a cage built on to the insectary in Pusa and was also found in cane in the

field. It was introduced to the insectary cage with the cane setts used for planting the cage.

As in all *Coccidæ*, the males and females are alike up to the second moult, when the male, after the moult, enters a period of rest during which it assumes a chrysalis form, while the female passes through another instar before attaining maturity, still as a wingless insect, after the third moult. Tabulating the stages simply we get the following table, in which the moults of one brood are given :—

1. Eggs laid	31-VIII	5-XII	15-I	1-III
2. Eggs hatched	11-IX	20-XII	31-I	16-III
3. First instar, both sexes, similar and active	4 to 6 days			
4. First moult	15 to 17-IX			
5. Second instar, both sexes, similar, active on occasion... ...	4 days			
6. Second moult	19 to 21-IX			
7. Third instar, males enter the pupal stage and rest ... Females remain as before and continue feeding	6 to 7 days			
8. Third moult, males emerged winged	26 to 27-IX			
9. Males fertilise females ..	28 to 29-IX			
10. Males die	29 to 30-IX			
11. Females lay eggs and then die ...	4-X	15-I	1-III	20-IV
Total duration of life ...	34 days	41 days	35 days	50 days

The above dates would show that there would be as many as eight distinct generations in a year ; actually there is a great deal of irregularity in the behaviour of broods and they overlap till all stages are found together. The table is drawn up from the earlier ones of the brood that could easily be followed, and even in the second generation there were at one time almost all stages represented together.

The egg.—When full grown and impregnated, the female fixes herself on a leaf or under a leaf sheath and commences to form an ovisac ; she secretes a mass of white cottony wax from the hind end and as this thickens, lays eggs in it and moves slowly forwards, depositing a covering of cotton with eggs inside. This completed ovisac is shown on Plate XII, fig. 1, the natural size ; it varies from 12 to 18 mm. in length and is about 4 mm. broad. The female dies

when it is completed, still at the end of it but falls off easily; a week was occupied by the completion of one ovisac by a female kept under observation.

In the insectary counts were made of the number of eggs; 7 females laid respectively 702, 653, 502, 490, 480, 400 and 320 eggs. Each egg is less than half a millimetre long, of the usual elongate oval outline, round in section; the egg is white when laid, becoming yellow later. The eggs are regular in hatching, their emergence being spread over as long a period as their laying occupied.

The Nymph.—On hatching, the little insect is about half a millimetre long; it is flattened, a little convex above, of a yellow colour. A delicate white mealy covering is soon formed (Plate XII, fig. 3). The antennæ and legs are well developed; the rostrum is on the ventral surface and there is a pair of eyespots near the base of the antennæ.

These little insects emerge from the ovisac some hours after they hatch and run actively about; finding a suitable spot on a leaf they settle down and fix the rostral threads in the tissue of the leaf. They scatter and spread over different leaves, fixing themselves in the shelter of the midrib. As growth continues, the white mealy covering increases and this spreads out into distinct white processes at the lateral margin. (Plate XII, fig. 4.) The anus is on the dorsal surface near the hind end, the liquid excretion dropping from the anal process on to the leaf below. At the moult, the skin with all its waxy appendages is cast and a new covering of wax is formed. As a rule, the bugs are inactive except at the moults; this applies to the male up to the second moult, the female throughout life. After the first moult the bug is about 1 mm. long, after the second about 1½ mm. After the third moult the females measure about 2 mm., and then they grow to 4 or 5 mm. The appearance of the fully grown female is shown in Plate XII, fig. 4.

Before the second moult, the male ceases to feed and seeks a sheltered spot, in a fold of the leaf or in the leaf sheath; it then moults and forms a white cocoon by the secretion of white cottony

material all round ; this cocoon is shown in Plate XII, fig. 2. The wing pads form gradually during the ensuing period of rest ; the pupa is shown on Plate XII, figs. 5 and 6. In the place of the developing mouthparts are two red spots, also seen in the winged insect and which may be sensory in function. The legs and antennæ are to some extent capable of motion, and the pupa can move along a flat surface. Under ordinary circumstances the insect remains motionless in the cocoon.

The male is shown in Plate XII, fig. 7 ; the antennæ are ten-jointed ; there are no mouthparts, in their place two dark red spots which may be sensory. There is the usual metathoracic process engaging with the anal angle of the wing ; the abdomen terminates in a pair of straight white processes. Males are active during the day and can be seen coupling. The process is short and one male visits several females. The females and males that emerge together from the third moult mate, so that impregnation follows very closely on this moult. The males then die, the females continue to feed, grow larger and then commence to form the ovisac described above.

The bugs are found in all stages upon the leaves of sugarcane, upon both the upper and under surfaces, but, as a rule, in a sheltered spot near the cane. They are found in numbers together, often on each side of the midrib of a leaf. They are distinct from the other cane Mealy Bugs (*Dactylopius sacchari*, *Ripersia sacchari*, *& Aclerda japonica*) in that they are not, as a rule, found on the cane beneath the sheathing leaves.

In a male up to the second moult and in the female throughout life, the rostrum can be withdrawn from the plant and the insect can move away to a fresh spot.

30. Dactylopius Virgatus (Ckll.).

This is a frequent pest of many cultivated and garden plants, occurring abundantly on the leaves and young shoots. Tree cottons especially Caravonica, were much infested at Pusa and in other localities in Behar, in Calcutta and at Coimbatore. Violets are constantly infested, and the bug in this case may be found on the

roots, root-stock or leaves. *Acalypha*, garden *Hibiscus*, croton, *Cissus discolor*, *Dracaena* are other food plants in India.

31. Ripersia Sacchari (Green).

The season of 1907 was marked by widespread disease of rice in Tirhoot and Behar, associated constantly with this insect. The bug occurred in numbers under the sheathing leaves, and on the stems ; the plants, both seedlings in the beds as well as young and old plants in the field, became yellow and withered ; how far the damage was due to drought, how far to the bug, or how far the weakness of the plants from drought favoured the increase of the bug is uncertain, but we would lay special stress upon the third of these considerations.

The insects were found inside the sheathing portion of the leaf and until this was opened there was no indication of the occurrence of the insect From one to forty bugs were found in the sheathing leaves of rice from Bankipur, closely packed together. (Plate XII, fig. 10.) There were no males or trace of male puparia and apparently males were not present nor were any found during the rearing and observation of the insect. Adult females measure 4 mm., are of an oval tapering form, and of a delicate rose pink colour. (Plate XII, fig. 11.) They are not clothed in mealy wax, but each nymph or adult produces white mealy wax, which either forms a distinct papery fabric below or, when many are massed together, forms a mealy white mass in which the insects are embedded.

The egg, laid by the adult female in the sheath, is oval, about a third of a millimetre long, of a yellow colour. (Plate XII, fig. 12.) There is no ovisac and the egg is simply laid on the leaf ; frequently one egg adheres to the next and they come out in a chain, joined end to end. (Plate XII, fig. 11.) The young nymphs (Plate XII, fig. 13) are active and fix themselves low down in the sheath in which they hatch ; they then remain there throughout life with only a short move at each moult. The older nymphs are extremely helpless and normally remain fixed in one spot. Both in cane and in rice plants, the bugs assume very distorted shapes due to the

pressure of the leaf sheaths, some being very elongated, others laterally compressed, others flattened at one part of the body only. It has not been possible yet to observe the details of a complete life-cycle, since the insects live wholly inside the sheath.

It was found that more than 75 per cent. of the insects from Bankipur were the hosts of parasites, Chalcids, of which more than one lives in each.

The bugs were also fed upon by the larva of a fly, which when full grown pupates among the mealy wax in the midst of the colony.

33. PHENACOCCUS ICERYOIDES (Green).

This occurred in dense mealy masses upon the common shrub *Capparis horrida* in Surat. It was attended by ants and was fed on by many larvæ of the Lycœnid, *Spalgis epius*, which, being themselves covered with white mealy wax and very slow in movement, were indistinguishable among the white masses of the bug. This is the only species on which we have found this remarkable Lycænid feeding, it having occurred upon the same bug and bush two years in succession at Surat.

36. TACHARDIA ALBIZZIÆ (Green).

Occurs in small quantities on *Nephelium litchi*, the cultivated Litchi tree. Its broods occur at different dates in Behar to those of *Tachardia lacca* and the question of utilising this species is under consideration.

38. TACHARDIA FICI (Green).

Is common on pipal in Behar; periodically the trees get so covered with lac as to be worth money, when they are sold to wandering lac buyers and the lac removed; several years then elapse before the tree again has a heavy crop: no attempt is made to inoculate or artificially cultivate the lac.

45. LECANIUM HEMISPHAERICUM (T. T.).

This insect is the notorious brown bug of coffee. It is also known on guava, *Thunbergia* and parwar (*Trichosanthes anguina*) in North

India, and on tea and loquat in South India. It has been for many years a serious pest to coffee in South India, in some instance destroying considerable areas of plant.

46. Lecanium Hesperidum (Linn).

One of the species kept by the red tree-ant (*Œcophylla smaragdina*) in its nests; the ant webs up the leaves round the twig on which the scale insects are, so covering it in.

47. Lecanium Imbricans (Green).

This insect, in its natural habitat upon the branches of the toon tree (*Cedrela toona*) in South India, is an extremely remarkable sight. The branches are covered densely by the large flat overlapping scales, which form a dense thick armour and it is not easy to say at first sight that the mass is formed of insects. Apparently it is a slowly developing species with two broods yearly at definite seasons. The amount of honeydew that falls from infested branches is large, producing much black blight on the coffee below and rendering the tree unsuitable as a coffee shade tree.

52. Lecanium Nigrum (Green).

This is common on cotton, infesting the smaller branches and twigs. It also occurs on bhinda (*Hibiscus esculentus*), gular (*Ficus glomerata*), *Justicia*, and on *Capparis sepiaria.* It is widely spread over India. A Hymenopterous parasite is found infesting the scales.

54. Lecanium Viride (Green).

The Green Bug of Coffee is slowly spreading further in South India among the coffee districts. It will in time be as serious an enemy to coffee in India as it was in Ceylon. The following was written in 1903:—

This insect is very closely allied to the Brown Bug and has a similar life-history. The bug is flatter, more elongated, of a deep green colour when full-grown and is readily distinguishable from all the scale insects previously described.

It occurs in the Pulney Hills, but it is uncertain in what other parts of India it is now to be found. Its food plants are varied and include guava, tea and coffee. The injury to coffee is similar to that caused by Brown Bug. It is a widely spread pest, occurring also in Ceylon, Mauritius and Brazil, and probably under other names in many other localities.

Recommendations.—There are three simple ways of dealing with these two pests (Brown and Green Bug), each available according to the particular circumstances of each coffee estate :

(1). If the bug is in the district or has previously been on the estate, and the estate is free from it, *keep the bug out.* Cut out all guava and loquat bushes or other plants that it will feed on ; watch for signs of its occurrence on the edges of the fields, and at once cut out and burn an infested bush.

(2). If the bug is already on the coffee in one or two places, stamp it out by cutting out all infested bushes and burning them on the spot. Then investigate those places to find how it came in and if guava, loquat or other plants are found infested, cut them out and burn at once on the spot.

(3). If the coffee is infested over any area, whether badly or only lightly, spray the bushes with insecticides. At first sight, this probably looks an impossible thing to do. Modern appliances, home-made or patent insecticides and careful work make spraying an easy and very effective business. I regard this as the safeguard of the coffee planter against brown or green bug.

59. Pulvinaria Psidii (Mask.).

The Green Mealy Scale of the shade trees of the coffee plant in the South of India. The following is reprinted from Insect Pests of Coffee :

(*a*). The Green Mealy Scale (*Pulvinaria psidii*) is the most serious enemy to the shade trees of Coffee at the present time.

Life-history.—The life-history is similar to that of other scale insects. The eggs are laid in large numbers in the mass of white cottony wax that lies behind and under the female insect. These eggs hatch to small flat insects, practically invisible to the naked eye, which walk actively about looking for a suitable place to

settle down and feed. Having settled down on a leaf or twig, they insert their beaks into the plant and feed on the juice. The insects increase in size and shed their skins twice. After the second moult, the insects are mature and when they have become full-fed, they lay eggs. Egg-laying is either carried out where the insect has spent its life or the insect migrates to another spot, usually on the lower side of the trunk of the tree, where it fixes itself and lays eggs; when egg-laying commences, the insect is green, flat and of its full size; as the cottony mass containing eggs grows larger under and behind its body, the insect shrinks and grows smaller, finally dying. Its shrunken body may be seen at the end of the large cottony egg-mass produced from its tissues.

This is the simple life history of the female. No male insects were found and it is probable that none occur.

Injury to trees.—This insect is injurious owing to its great abundance on the trees it attacks. When a tree is covered with the young insects, the loss of sap is so large that the tree is killed or very much weakened. In addition this pest, like the others, produces "Black Blight" on the coffee bushes below and on neighbouring trees, and so does additional damage.

Enemies.—The green mealy scale is attacked by other insects. The most important of these is a fly maggot, which lives in the white egg-masses, eating the eggs. The maggot is hard to find and when full-fed, it turns to a small brown seed-like pupa and from that a small fly emerges. Without very careful searching, it is not possible to find this maggot and the fly is so small it could not be recognised except by an expert. The simplest way to know if this enemy is present in a locality is to place large quantities of the white egg-masses in a box with a wire-gauze or glass top and see if flies emerge from the egg-masses after a fortnight or longer.

The second enemy is the caterpillar of a small Tineid moth; this caterpillar can be found on the bark of badly infested trees; it spins webbing over the egg masses and lives under this, feeding on the scale and the eggs. Apparently it is not common.

In some cases a large percentage of the young scales were found to be dead. This is probably due to disease and there is evidence that this takes place in wet localities. In places where the rainfall is high and the conditions are favourable to the spread of this disease, a large proportion of the scale is apparently destroyed during part of the year, and this appears to account for the small quantity of this scale found in some localities.

Food plants.—The green mealy scale attacks the Utty (*Ficus glomerata*) chiefly, as well as the Nundi (*Lagerstrœmia lanceolata*) and the Gundal or Goondal (Kanarese name). It is also found on guava (*Psidium guava*), loquat (*Eriobotrya Japonica*), and some other trees that are grown in coffee districts.

Origin.—"*Pulvinaria psidii*" is recorded from New Zealand, Hawaiian Islands, Formosa, Ceylon, China, Japan and California on a variety of plants. (Fernald, Coccidæ of the World.)

It is, therefore, impossible to say whether it is a native of the East or of India, or whether it has been introduced into South India. Its food plants include guava and other common plants which would very much assist its spread over India, and the practice of planting the roads with "Utty" and such trees will also help it to spread in South India. It is already abundant on some of the North Mysore roads.

In South India, it occurs in Mysore, Shevaroys, Coorg and the Nilgiris.

Spread.—When this insect reaches a favourable locality, it appears to spread comparatively rapidly over a large area. When we remember that at no stage can the insects fly, that they walk, as a rule, only when quite young or when mature, and that they are of very small size with very deficient eyes, it seems amazing that they should spread so rapidly. It is possible that birds, monkeys and other animals may carry the eggs from tree to tree, but so far this has not been proved. The greatest aid to spread appears to be the falling leaves of attacked trees. Leaves falling off a tree have scales on them, and these may be laying, or have laid eggs on the leaves. The young then hatch and walk about; their instinct apparently is to go up, as in very many Coccidæ, and we find many young ones walking up the stems of the shade trees. This is easily shown by the tar ring described below. Such falling leaves are blown for some distance, and, probably, this accounts for the rapid spread of this species of scale insect. Many of the young possibly do not ever reach a tree and settle down on the coffee bushes, where they are able to live, though they apparently prefer the "Utty" trees.

Treatment.—In every case planters must determine for themselves how far it is necessary to treat the shade trees or to take any steps against the scale. The following recommendations are made and *all* should be adopted where the green mealy scale is proving destructive :—

(1). *Replace the attacked shade trees.*—Trees that are not attacked and which are known to suit the particular locality should be sown or planted wherever there are attacked shade trees to be replaced. The attacked trees can then be *gradually removed* as the new shade takes its place. The attacked trees should not be felled or ringed in large numbers at one time, but gradually.

(2). Paint a four-inch ring of tar round the trunk of attacked trees, below the lower branches, but above the coffee.

The same should be done to all "Utty" and other trees that are liable to attack.

This to a great extent hinders the spread of the scale and will also destroy a great number.

Young ones that hatch on the ground from eggs on fallen leaves walk *up* the trees to reach the leaves. Many mature females move down the trees to find a suitable place on the trunk to lay eggs. Both of these are caught and destroyed in the tar rings.

This is especially valuable where a few trees are affected and the attack is likely to spread to other trees close by.

(3). Maintain the vigour of coffee and shade. The importance of this is discussed in a separate paragraph on page 16.

(4) Watch carefully for signs of the entrance of the pest if it has not come or of its spread if it is in the district. It is also important to watch for its attack on *coffee*. It is known that the insect can live on coffee bushes, and it is liable to do so. This would need to be instantly checked and it is important to bear this in mind.

63. Ceroplastes Floridensis (Comst.).

Occurs in small numbers on Bhinda (*Hibiscus esculentus*), Guava (*Psidium guava*), Mango (*Mangifera indica*), Guar (*Cyamopsis psoralioides*), Pakur (*Ficus infectoria*) and Jhao (*Tamarix gallica*). The scales are very often solitary and we have seen no instance of damage caused by them.

Aspidiotus Aurantii (Mask.).

Has occurred abundantly on citrus at Pusa introduced with plants from other localities in India. Spraying and rubbing the stems with insecticides has checked but not exterminated it and ultimately fumigation with Hydrocyanic acid under cloth covers was resorted to, thoroughly clearing the infested standing bushes.

Where this scale occurs on young Citrus plantations, fumigation is the best remedy and is perfectly feasible.

81. Aspidiotus Triglandulosus (Green).

This occurred abundantly on forest trees in Mahableshwar, Bombay, in March 1904.

Mytilaspis Lasianthi (Green).

Specimens of this species were collected upon croton in Calcutta and identified as this species by Mr. Green, who has accidentally omitted it from his list of species. It was possibly an importation as it has only once been found.

DESTRUCTIVE SPECIES.

The student of this group will find that there are few references in the literature of Indian species to the destruction caused to economically valuable plants. It requires more than a single plant infested once, or even a number of plants constantly but sparsely attacked to constitute a scale insect as a pest or to brand it as destructive, and while the group as a whole are elsewhere destructive, individual species are comparatively seldom found to be so in this country. In a recent Memoir (Vol. I, No. 5) the species injurious to tea were discussed, but with the remark that "fortunately very few of them are of serious consequence at present". The same would probably be true of the species attacking coffee were the industry a more flourishing one and were the cultivation maintained at a high level; *i.e.*, if the coffee plant was kept at its maximum vigour, green and brown bug would probably be of much less importance. Apart from these two crops, there is very little that can be assigned to this group. The species of *Monophlebus* are occasionally injurious but they look far worse than they are; we have actual cases where heavy infestation of the flowering shoots of mango, or of the fruit stalks of mango and jack-fruit have led to the withering of the shoot or fruit so completely that a considerable actual loss occurred; this was notably the case in Tirhoot in 1908, when the bugs were extremely abundant. The fact that this insect has but one yearly brood coinciding with the rise of sap in the plant would account for its usual harmlessness, and except in these special and apparently rare cases, no harm seems to be done.

Icerya Aegyptiaca (Dougl.).

Is unpleasant in gardens where ornamental crotons are grown, and is, in this way, a minor garden pest.

Cerococcus Hibisci (Green).

Has been reported as destructive to cotton and might be a very serious enemy to this crop were it not often and so heavily parasitised. The spread of this species minus its parasite to cotton-growing countries might be a serious matter.

Dactylopius Citri (Risso).

Has been important as an enemy to young coffee plants in the nursery and as such is a destructive insect.

Dactylopius Nipæ (Mask.).

Apparently plays an important part in the destruction of seed potatoes in Bengal ; whether it does so directly or as a carrier or inducer of other forms of disease is uncertain, but its presence is associated with widespread loss.

Dactylopius Sacchari (Chall.), Ripersia Sacchari (Green) and Aclerda Japonica (Mask.).

Are all found together on cane, and it is not an uncommon thing to find canes with dense colonies of these insects under the sheathing leaves. Actual lessening of the yield of sugar is stated to occur, as well as a deterioration in the quality ; and we may rank these three species collectively as being of a considerable degree of importance. In the case of *Ripersia sacchari*, Gr., we have its further occurrence as a widespread pest of rice in the dry year 1908 ; this requires further investigation ; as stated above, the insects were found to be heavily parasitised towards the end of the attack, and it is by no means certain that the bug itself was the direct cause of the withering of the plant.

Of *Lecanium*, we have no recorded cases of actual damage save in the case of the species attacking coffee.

Pulvinaria Psidii (Mask.).

Has been a serious pest to the coffee planter from its ravages on the shade trees ; it has been curiously abundant on trees grown as shade, and, to a less extent, to the same trees growing wild or in avenues on roads. It has no significance as a pest apart from its occurrence on coffee shade trees but is then important.

Aspidiotus Aurantii (Mask.).

The red scale of orange has proved injurious upon citrus trees grown in gardens ; the important citrus cultivations of Nagpur and the Khasi Hills are apparently not attacked and this is a potential, rather than an actual, injurious insect in this country.

Aspidiotus Destructor (Sign.).

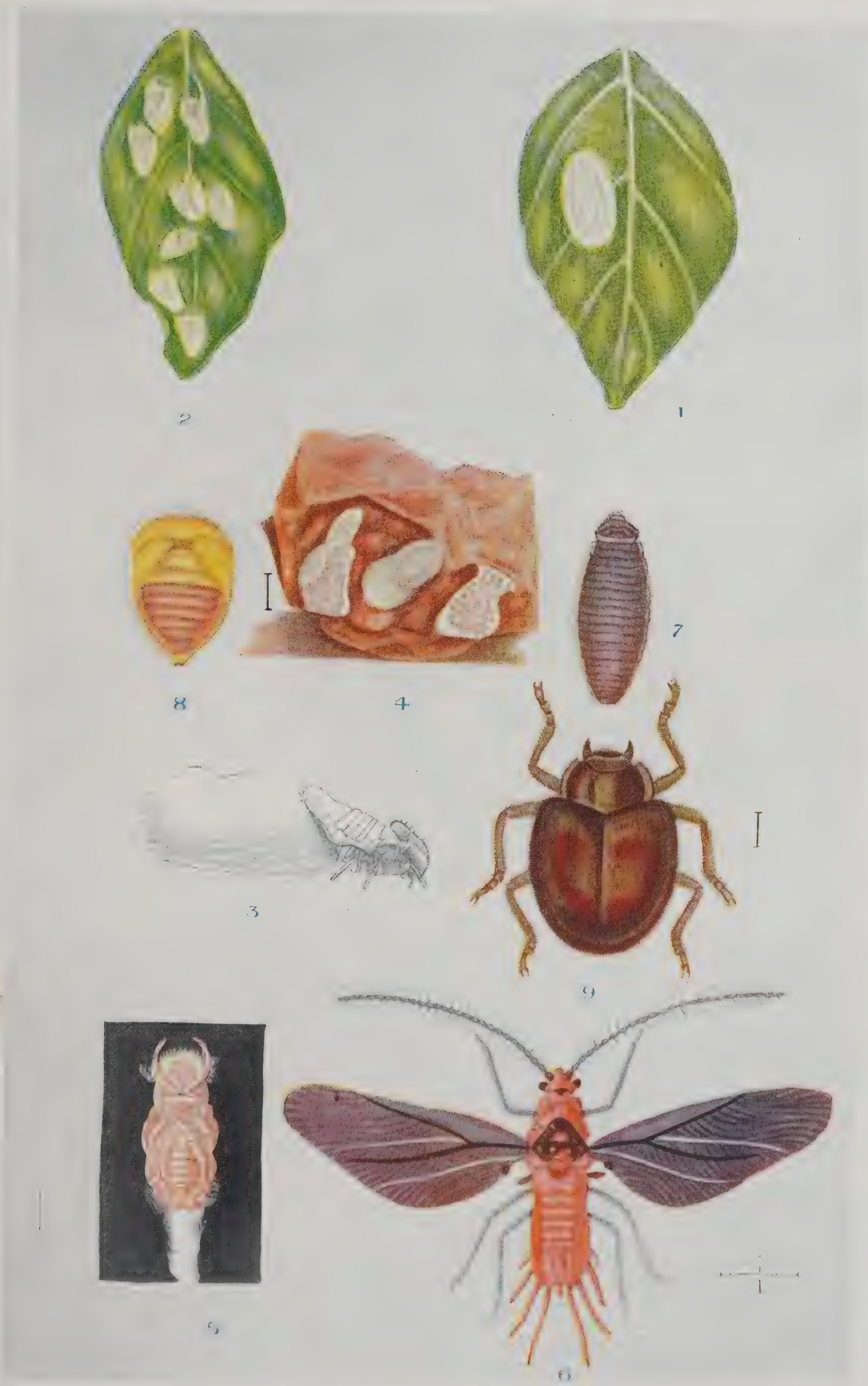
On mango and on palms has been injurious but only in isolated instances ; the same is true of *A. ficus*, Ashm., on citrus and areca palm.

The above practically summarises the economic position of this group, and it is evident that they hold a very minor position as pests to what they do in some other countries ; there is nothing to justify elaborate measures for keeping them out, as is done elsewhere ; there is equally nothing to justify anything approaching to the strenuous efforts made to check inter state spread of some species in the United States. Why it should be so is not very clear ; a climate of fierce extremes, the absence of exotic fruiting plants weakened by too heavy cropping, an active season for their parasites and enemies coincident with their own, the absence of large continuous areas of permanent fruit or other crops: all these may be operative singly or jointly with many others of a more obscure nature. There is, however, little actual importance in the group and no reason to think that they will ever attain the degree of importance they and their allies do in other countries.

EXPLANATION OF PLATE X.

MONOPHLEBUS STEBBINGI GR. VAR. OCTO-CAUDATA (Gr.).

Fig. 1. Adult female, after last moult.
,, 2. Exuviae of nymphs.
,, 3. Female and ovisac.
,, 4. Females egg laying under a piece of brick.
,, 5. Male pupa.
,, 6. Male imago.
,, 7. *Aulis vestita* Muls, larva.
,, 8. *Aulis vestita* Muls, pupa.
,, 9. *Aulis vestita* Muls, imago.



MONOPHLEBUS.

Engraved and Printed
by The Calcutta Phototype Co

EXPLANATION OF PLATE XI.

Icerya minor (Gr.).

Fig. 1. Egg before hatching.

,, 2. Just hatched nymphs seen under a very low power lens (see fig. 7).

,, 3. Advanced nymphs in the first stage showing the waxy tubes through which drops of secretion are thrown out.

,, 4. Pupa dorsal aspect (male).

,, 5. Pupa ventral aspect (male).

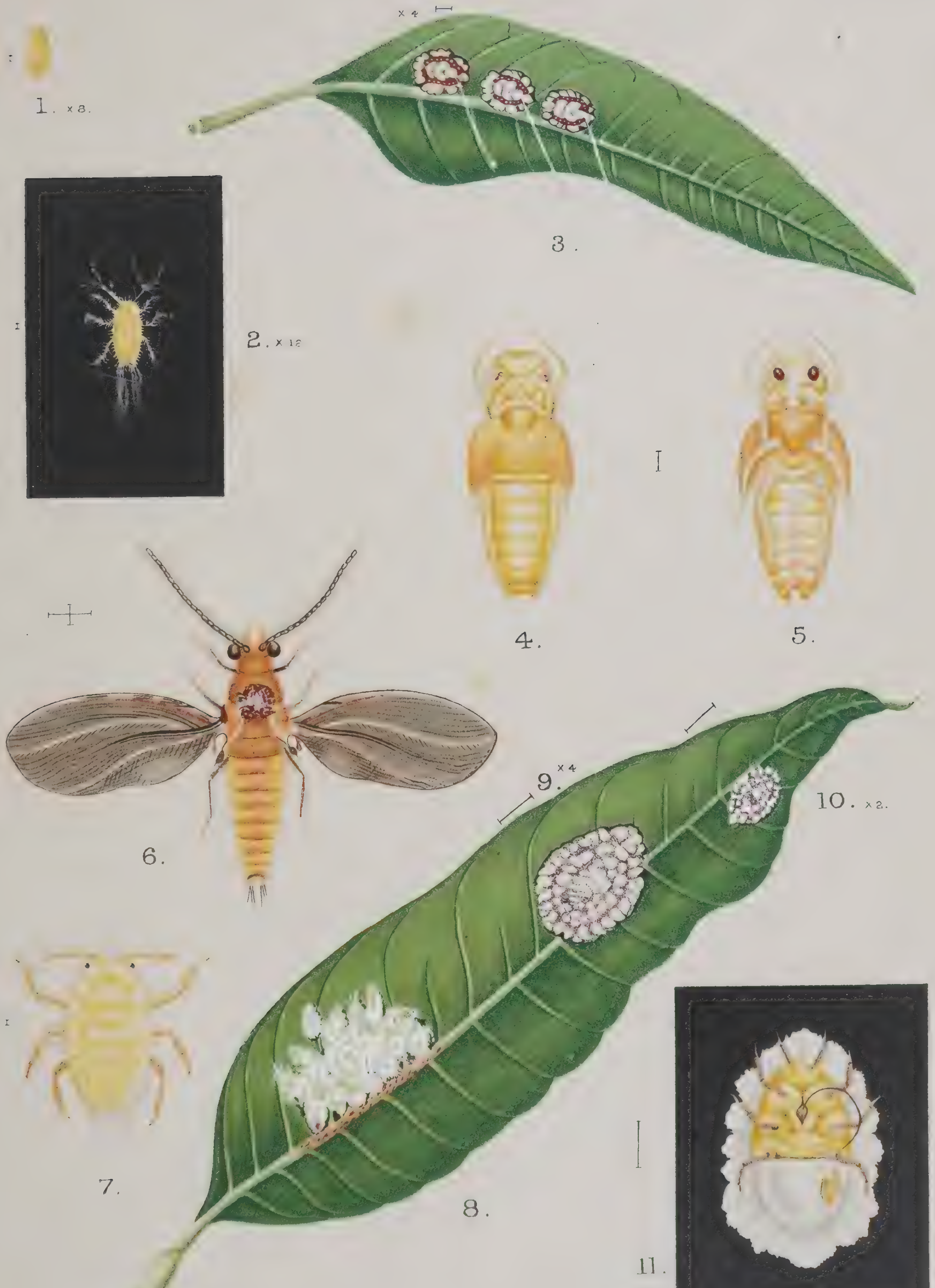
,, 6. Winged male.

,, 7. Newly hatched nymph seen under a very high power lens.

,, 8. The cottony mass in which the males pupate.

,, 9 & 10. Grown up females.

,, 11. Ventral view of the full-grown female with the ovisac covering the whole abdomen; some of the eggs being exposed.



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ICERYA MINOR Gr.

EXPLANATION OF PLATE XII.

Dactylopius sacchariforlii (Gr.).

Fig. 1. Female and Ovisac. x1.
,, 2. Male cocoon. x1.
,, 3. Newly hatched nymph. x18.
,, 4. Full-grown female.
,, 5 & 6. Pupa. x30.
,, 7. Male.

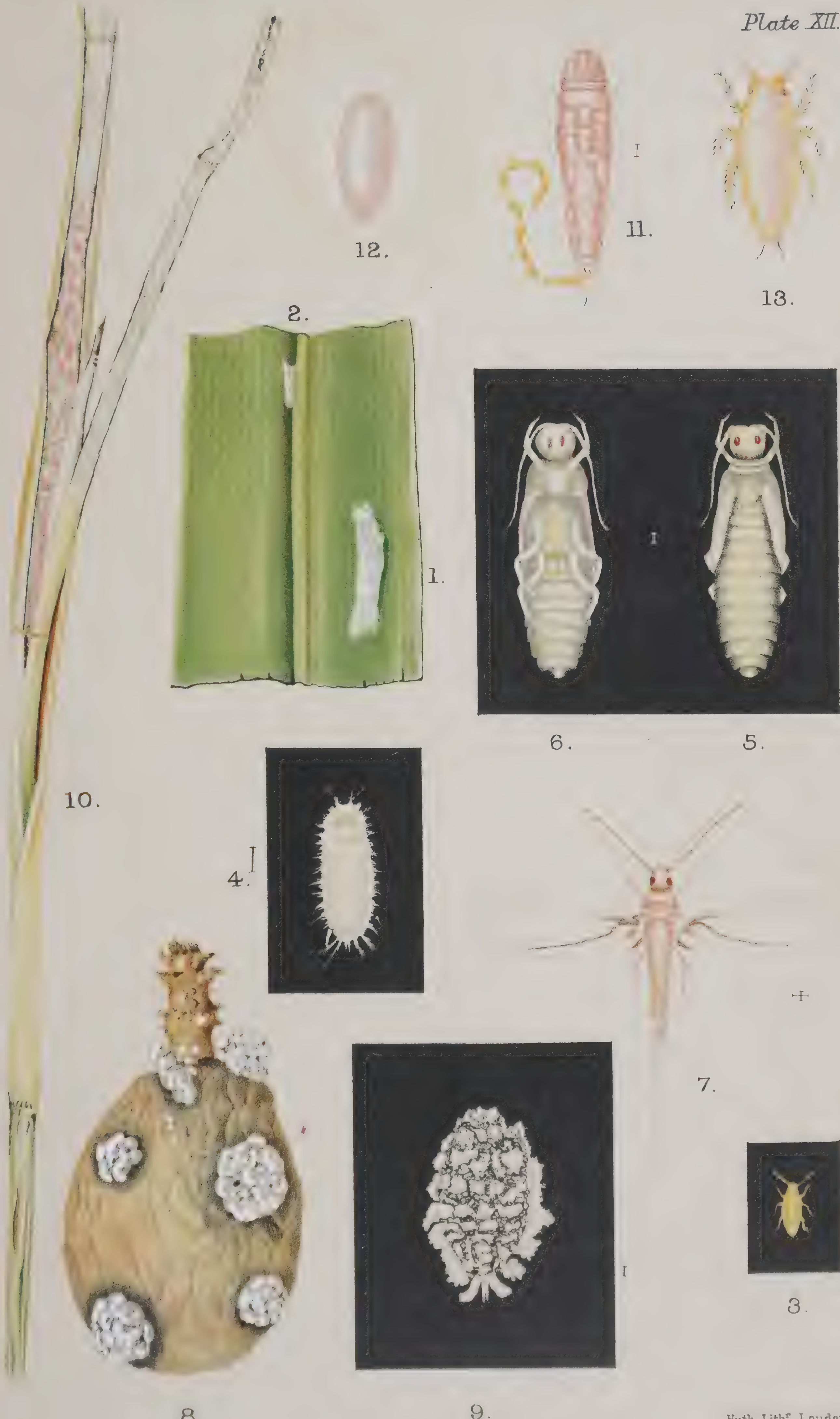
Dactylopius Nipæ (Mask.).

,, 8. A potato with the clusters of bugs at the eyes.
,, 9. A female bug.

Ripersia sacchari (Gr.).

,, 10. Bug clustered in leaf sheath of rice.
,, 11. Mature female laying eggs.
,, 12. A single egg. x50.
,, 13. Newly hatched nymph.

Plate XII.



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INDIAN COCCIDAE

LIFE-HISTORIES OF INDIAN INSECTS (COLEOPTERA I.)

By H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

I. Phyllognathus Dionysius (Fabr.).

This species was sent in from Belgaum, Bombay Presidency, in July 1907, as injurious to the rice crop. The report of the Mamlatdar of Belgaum was as follows :—

"I have the honour to report that a kind of white worms, locally known as 'Roti hula,' has appeared in the rice-fields of Kannabargi, a few specimens of which are sent herewith. They are said to have germinated in the stubbles of jowar, sown for fodder along with rice last year, and they also take birth out of manure used in fields.

When I visited the village this morning, I enquired from the ryots as to the cause of their appearance this year, and was told that they are produced with the first rain every year, but when there is rain enough for water to stand in the fields, they die out. As there have been no heavy showers this year they have held on and are now attacking the roots of the paddy seedlings. They eat up the roots, and the plants wither away. They have grown so plentiful that as many as two hundred worms can be taken out of an area of one guntha. They are not found above ground, but 3 to 4 fingers under the ground along with the level of the roots and in black soil rice-fields only. They attack not only paddy seedlings but also all sorts of green vegetation. The mischief that these worms are doing is causing serious alarm among the ryots, some well-to-do among whom have already sown their lands again, and if good rain does not come in time, these insects will remain to do damage to the growing plant, the extent of which cannot be estimated now."

As no further report was received, it is presumed that the damage was not as great as had been anticipated. The larvæ were reared in the insectary, and from the imagines eggs were obtained and the full life-hsitory worked out in detail as given below.

Phyllognathus is placed in "Group IV, *Oryctides vrais*" of the Cyclocephalide sub-family of Dynastidæ (Lacordaire); it is distinct from *Oryctes* in the absence of stridulating organs. Five species are listed in the Munich catalogue, one only from India. The species was described by Fabricius (Ent. Syst. I, p. 20), is referred to by Burmeister (Handl. V, p. 188), by Lacordaire (Gen. Col. III, p. 429). Its distribution is given as "India or" and "Bengal," both wide terms. We have specimens from Belgaum, Igatpuri, Seoni (Central Provinces) and Pusa, showing that it is widely spread in India and probably common.

Life-History.—Larvæ were received on July 14th, 1906, from Belgaum. These were reared and became beetles between the 5th September and the 3rd October of that year. They remained inactive in the soil until May 1907; eggs were laid between the 4th June and the 20th July 1907. These hatched, were reared and came out as adults in September 1907. The life-history then is as follows:—

Eggs laid	June-July.
Larval life	July, August, September.
Pupal life	Part of September or October.
Imaginal life	October to June.

The only active life is the larval period and the brief period when the adults mate and lay eggs.

The Egg.—The beetles were kept in glass dishes with two inches depth of loose soil; eggs were laid in this soil singly and at night only. From eight females only 34 eggs were obtained, but probably all did not lay eggs. The eggs are white; before hatching the grey colour of the hind end of the larva and the brown of the mandibles can be seen through the soft elastic shell. When first laid, the egg is oval in outline, about 2 mm. long, 1·5 mm. in breadth. In a short time it grows larger and rounder, measuring

3 to 3·25 mm. in diameter; with increase in size is increase in weight; a single egg weighing ·04 grain when laid, increased to ·16 grain before hatching. Probably this is due to the absorption of moisture from the damp atmosphere of the soil.

Four eggs were kept under daily observation and behaved as follows :—

20th	July	—Eggs laid during night.
21st	,,	The eggs were oval, 2 × 1·75 mm. Total weight 2·4 grain, individual weight ·6 grain.
22nd	,,	Egg A was bigger, nearly round, 2·5 mm. in diameter, weight 1 grain. The remaining three unaltered, total weight 2·1 gr.
23rd	,,	Egg A, diameter 3 mm., weight 1·8 gr. Egg B, round, diameter 2·5 mm., weight 1·5 gr. Eggs C & D, together weighed 2·1 gr.
24th	,,	Eggs A & B, diameter over 3 mm., weight 2·25 gr. Eggs C & D, diameter nearly 3 mm., weight 2 gr.
25th	,,	A & B became oval, 3·25 by 3 mm. each, weight 2·4 gr. C & D were round, 3 mm., weight 2·2 gr.
27th	,,	C hatched in afternoon. B & D hatched at night.
28th	,,	A hatched.

The grubs also vary in size, that hatching from A being 8 mm. long, the other three 6·5 mm. Emergence takes place by the rupture of the shell, first by the mandibles of the larva, then by its struggles; it emerges with portions of the egg shell adhering to it.

The following table shows the duration of the egg stage :—

Eggs laid.	Eggs hatched.	Duration in days.
4-VI (night) ...	10-VI	5
6-VI ,, ...	12-VI	5
7-VI ,, ...	12-VI (afternoon) ...	5
16-VII ,, ...	22-VII (morning) ...	5½
16-VII ,, ...	22-VII (night) ...	6
16-VII ,, ...	23-VII (morning) ...	6½
20-VII ,, ...	27-VII (afternoon) ...	6½
20-VII ,, ...	27-VII (night) ...	7
20-VII ,, ...	28-VII (evening) ...	8

Larva.—On hatching, the larva is 6 to 8 mm. long, flattened dorso-ventrally. The head soon becomes brown; the antennæ are five-jointed. The segments are much wrinkled and the abdomen is curled round on itself. The anal segment is grey, the rest of the body white. There are nine pairs of prominent yellow spiracles. The three pairs of legs are brown, the tarsus one-jointed with a single claw. The body is clothed in short brown hairs. There are practically no important changes during larval life; the anal segment becomes larger, darker in colour; the larva measures 36 mm. in length, with a breadth of 6 mm. Larvæ were maintained alive successfully in a metal cylinder two feet in diameter, containing a foot depth of soil on which rice grew. It was impossible to observe them accurately, but they ate the roots of the rice and were quite healthy. The only indication of their presence at the surface was small masses of pellets of earth thrown up near the plants, much in the manner of an earthworm. Larval life lasted for over three months, grubs hatched on June 10th, pupating on September 20th.

The Pupa.—When full-grown, the larva burrowed down into the soil to the depth of a foot, made a chamber in the soil with somewhat hardened walls and pupated. The pupa (Plate XIII, figs. 6—8), is about 20 mm. long by 10 mm. wide; it is curved, the ventral surface concave. The spiracles on the 2nd, 3rd and 4th abdominal segments are prominent, the remainder smaller. Pupation occupies eight days.

The Beetle.—Males and females are about the same size, the male with dilated fore tarsi, and with a vertical horn of the head. (Plate XIII, fig. 10.) The beetle remains in the pupal chamber from September to May. This is a curious fact; apparently the soft unchitinised pupa is less well able to resist climatic changes than the highly chitinised beetle. Beetles removed from the pupal chambers buried themselves in soil and remained motionless until May.

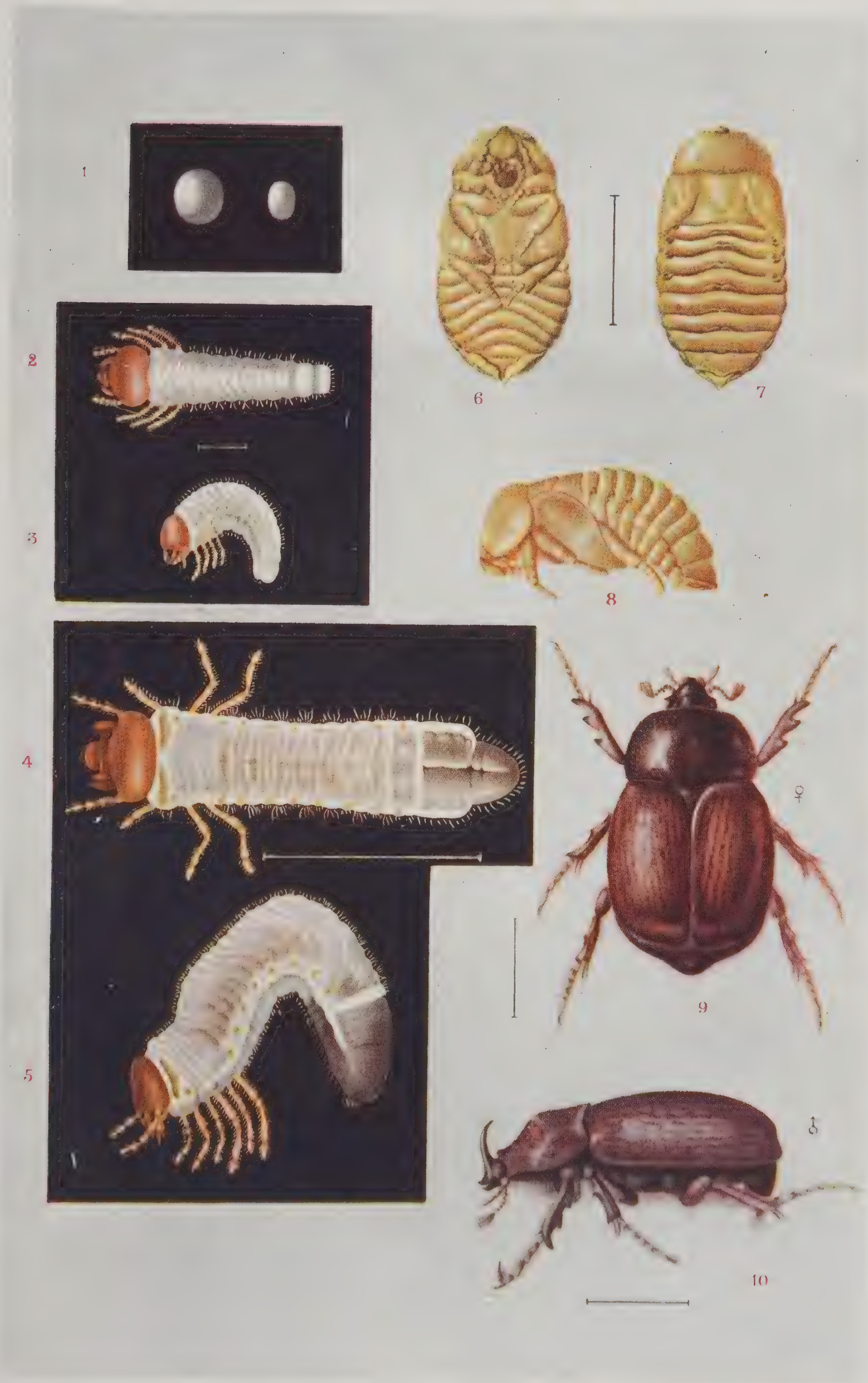
In May all became active, paired and then eggs were laid in early June. No food was eaten so far as could be seen. The beetles are active at night only and have been captured at light. The reared specimens taken from the pupal chambers in October

EXPLANATION OF PLATE XIII.

PHYLLOGNATHUS DIONYSIUS.

Fig.	1.	Egg when laid and just before hatching.		
,,	2.	Young larva, dorsal aspect.		
,,	3.	,, ,,	lateral	,,
,,	4.	Adult ,,	dorsal	,,
,,	5.	,, ,,	lateral	,,
,,	6.	Pupa	ventral	,,
,,	7.	,,	dorsal	,,
,,	8.	,,	lateral	,,
,,	9.	Beetle, female,	dorsal	,,
,,	10.	,, male,	lateral	,,

PLATE XIII.



PHYLLOGNATHUS DIONYSIUS

coupled in some cases, but both sexes lived until May and the females laid eggs which hatched normally. The males die soon after egg-laying, the females may live on till September. All the males were dead by July 15th, while the last female died on the 3rd September.

II. Anomala Varians.

Anomala Varians.—(Oliv.) (Ent. I, 5, p. 78, t. 10, fig. 123 a.b.), *elata* Fabr. Ent. Syst. 1, 2, p. 161—Burm. Handb. IV, 1, p. 233.

The genus Anomala is placed by Lacordaire in the sub-family *Rutelides*, and with *Mimela*, *Phyllopertha*, *Rhinyptia*, etc., in the second sub-tribe Anomalides. As understood by him, it included species in all continents, with several in India ; Gemminger and Harold's catalogue (1869) gives 39 species from the continent of India, and seven have been described from India since.

Distribution.—The species was described from Coromandel and India We have it from Surat, Khandeish, Canara, Yercaud, Baroda, Pusa. It is the common species general in Tirhoot, Gujarat and probably many other cultivated areas in India.

Life-History.—Larvæ were collected from a plot of sugarcane on the 27th July 1906 ; the plot was overgrown with motha grass (*Cyperus rotundus*). They were kept alive in the insectary in earth and fed on the roots of rice and grass. In September they descended to the bottom of the big cylinder they were kept in and prepared each a chamber of consolidated earth, in which they rested. Even when the soil dried, the earth forming these chambers remained moist, possibly from moisture excreted from the insects. They rested until May 1907, when they pupated and appeared as beetles.

A cage was then prepared and rice sown ; a few beetles were put in on June 1st, 1907, and on the 15th July, young and half-grown grubs were found ; these behaved as did their parents, only emerging as beetles in April 1908. The life-history of a particular brood is :—

Eggs laid	... 1st June.
„ hatch	... 10th June.
Larvæ feed	... June to September.
„ rest	... September to March.
Pupated	.. 30th March
Beetle emerged	... 9th April.

During July-August, larvæ of varying sizes will be found, since the beetles emerge, mate and lay eggs at varying dates from April to June.

Egg.—The egg is, when laid, about 2 mm. long by $1\frac{1}{2}$ mm. broad, elongate oval in shape, with rounded ends. The colour is white, the surface smooth without ornamentation. The egg weighs about ·06 grain. During the first two days the egg becomes round, larger and heavier. On the third day, it is nearly round, $2\frac{1}{4}$ mm. in diameter and weighs ·11 grain. When fully developed, the egg is about $3\frac{1}{4}$ by 3 mm. and weighs ·14 grain. The colour is then a deeper white, with a faint pink tinge, and the brown mandibles are clearly visible through the thin shell.

The egg shell bursts into several pieces, some of which adhere to the larva till they are brushed off as it moves through the soil.

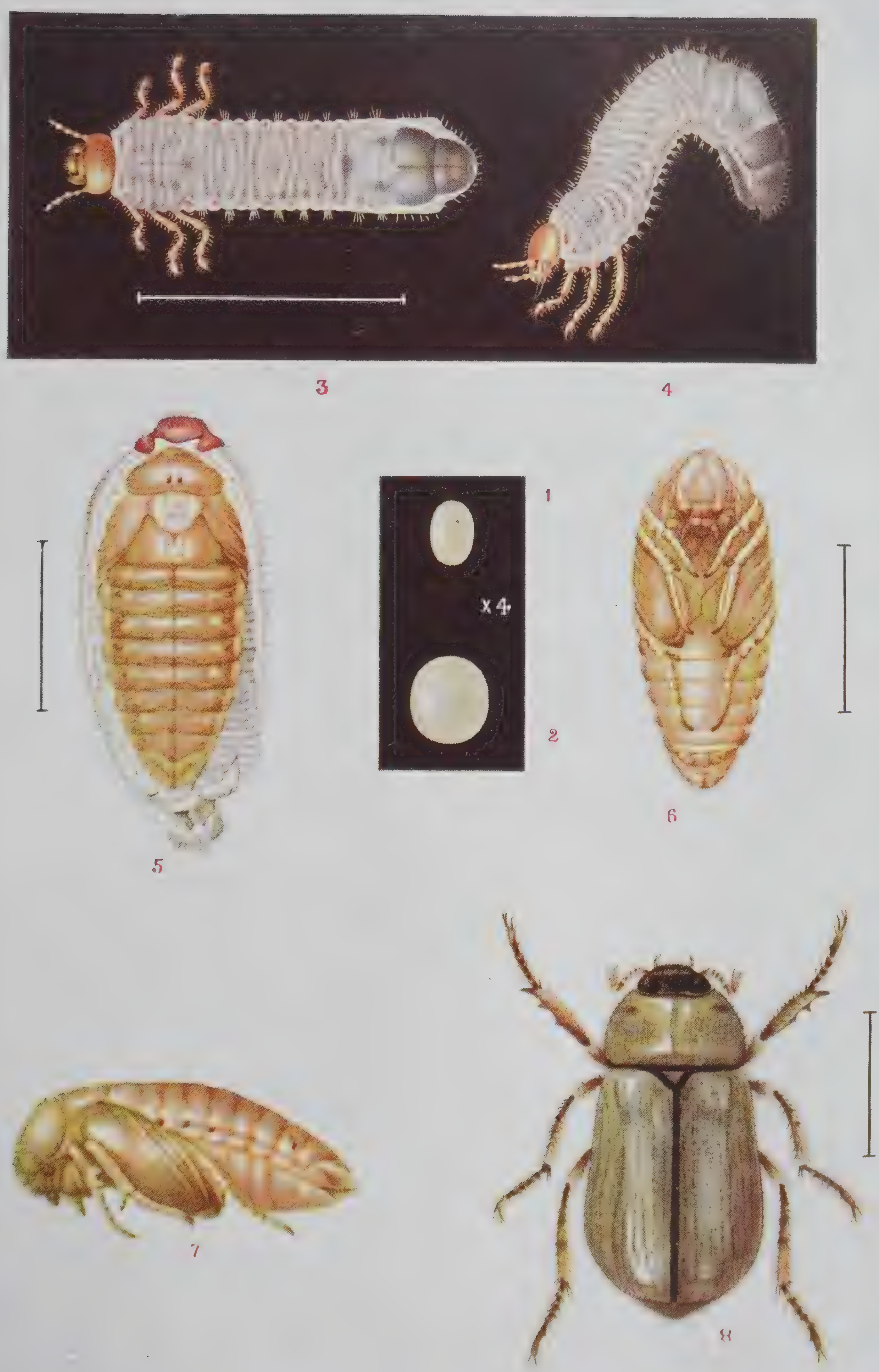
Larva.—The young grub measures 6 mm. in length by about 2 mm. in breadth ; the body is curved, the abdomen curling in ventrally under itself. The head is light-yellow, hard, with the mouth-parts dark-brown ; the antennæ are small, five-jointed, a small basal joint and four distinct free ones. The legs are well developed, set with stiff hairs and having a single tarsal hook. The body is much wrinkled, white in front, the curved posterior part grey ; it is set with small stiff spines and with longer brown hairs ; there are small brown spiracles. The full-grown larva is 38 to 40 mm. long, flattened, about 9 to 10 mm. broad. The head is yellow, about 5 mm. wide, with red mouth-parts and black-tipped mandibles. There is a small yellow chitinised patch on each side of the prothorax above. The segments are much wrinkled except the eighth abdominal and hind end, which are smooth, grey and shining. The only hard parts are the head, legs and the prothoracic patches ; the larva moves about in the soil, forcing its head through and dragging the soft body behind it ; the backward set of the hairs and spines on the uncurved part of the body helps it and the end of the abdomen that is bent forward under it, is smooth and moves easily. The food is the roots of plants ; so much earth is contained in the excrement that it was thought the food might be earth, but batches of larvæ given only moist earth always

EXPLANATION OF PLATE XIV.

ANOMALA VARIANS.

Fig. 1. Egg when laid.
" 2. " just before hatching.
" 3. Larva, dorsal view.
" 4. " lateral view.
" 5. Pupa, dorsal view, in the last larval exuvium.
" 6. " ventral view.
" 7. " lateral "
" 8. Beetle.

PLATE XIV.



ANOMALA VARIANS.

died, whilst those under similar conditions given roots throve. The former lived from 16 to 21 days, but scarcely increased in size at all. When full-grown and resting, the larva shrinks a little, becoming shorter ; when it pupates the skin bursts along the mid-dorsal line from the prothorax backwards and in front along the head to the vertex where the split bifurcates to the antenna on each side. The pupa does not emerge from the skin, but lies partly enveloped in it, and when the beetle emerges, the pupal skin is left in the larva, so that both are found together in the cell from which the imago has escaped.

The pupa (Plate XIV, figs. 5—7) is 24 mm. long by about 10 mm. broad in the middle. The dorsum is convex and the pupa is curved ventrally, the head not being visible from above. At the posterior margin of the pronotum is a pair of small fleshy protuberances, on each side of the median line. The disposition of the wings, legs, etc., is shown in the figures. The abdominal segments can be moved in the dorso-ventral plane. The spiracles on abdominal segments 2 to 4 are large and prominent, those on 5 to 8 smaller.

The largest number of eggs laid by a beetle in captivity has been 30 ; this beetle was captured on 5th May, laid 5 eggs on the 10th, 13 on the 11th, 12 on the 12th and then died. Another, caught on the 11th, laid 8 eggs on the night of the 14th, 1 on the 17th and then it died. Another caught on the 9th, laid 14 eggs on the 16th and died on the 19th. Eggs are laid at night in the soil, at a depth of two or three inches, singly.

The beetle is nocturnal in habit ; it flies about in the dusk and comes freely to light. Stragglers are out in April, but the main body comes out after a good shower all about the same date. In 1908, a little over half an inch (·53) of rain fell on May 9th, and on the night after, great numbers of *Anomala varians* were out.

Occurrence.—This insect is found commonly at Pusa and it is the most abundant cockchafer larva found attacking crops so far as at present observed. In only one year have its attacks done marked damage, when groundnut was the crop attacked ; this occurred in the first year that the land was cultivated (1904).

It is also found abundantly in Gujarat, at the roots of Juar (*Andropogon sorghum*), bajra (*Pennisetum typhoideum*) and other millets ; they are also found at the roots of sugarcane in Gujarat and Behar. Until quantities of such larvæ have been reared, it is impossible to tell what species are concerned, but in view of the wide distribution of this species in the plains, its abundance and its habits, it is likely to be one of the important and universal cockchafers destructive to Indian agriculture.

Remedies for such larvæ in land depend so entirely on local conditions that it is useless recommending anything for general adoption. We know as yet very little of the species destructive to crops and especially of their seasons. Nor does this knowledge in the two cases above help us very much ; ploughing in India is usually too light to affect larvæ or pupæ in the soil unless they are actually in the feeding larval state near the surface. Dressings such as gas-lime, kainit, etc., are impossible and the cost of applying the much-advertised patent preparations is too great (Rs. 30/- per acre) to be worth consideration.

GALERUCELLA.

This genus is placed in the Galerucide sub-division of the subfamily *Galerucinæ* of the division *Cyclica* of the *Chrysomelidæ*. The Munich catalogue enumerates a number of species, widely spread, with four from Nepal ; at least three more Indian species have been since described.

The life-history of the two species is shown here ; one is *G. rugosa*, Jac. ; the other, an apparently undescribed species, to which might be given the name *G. singhara*.

GALERUCELLA SINGHARA. (The Singhara beetle.)

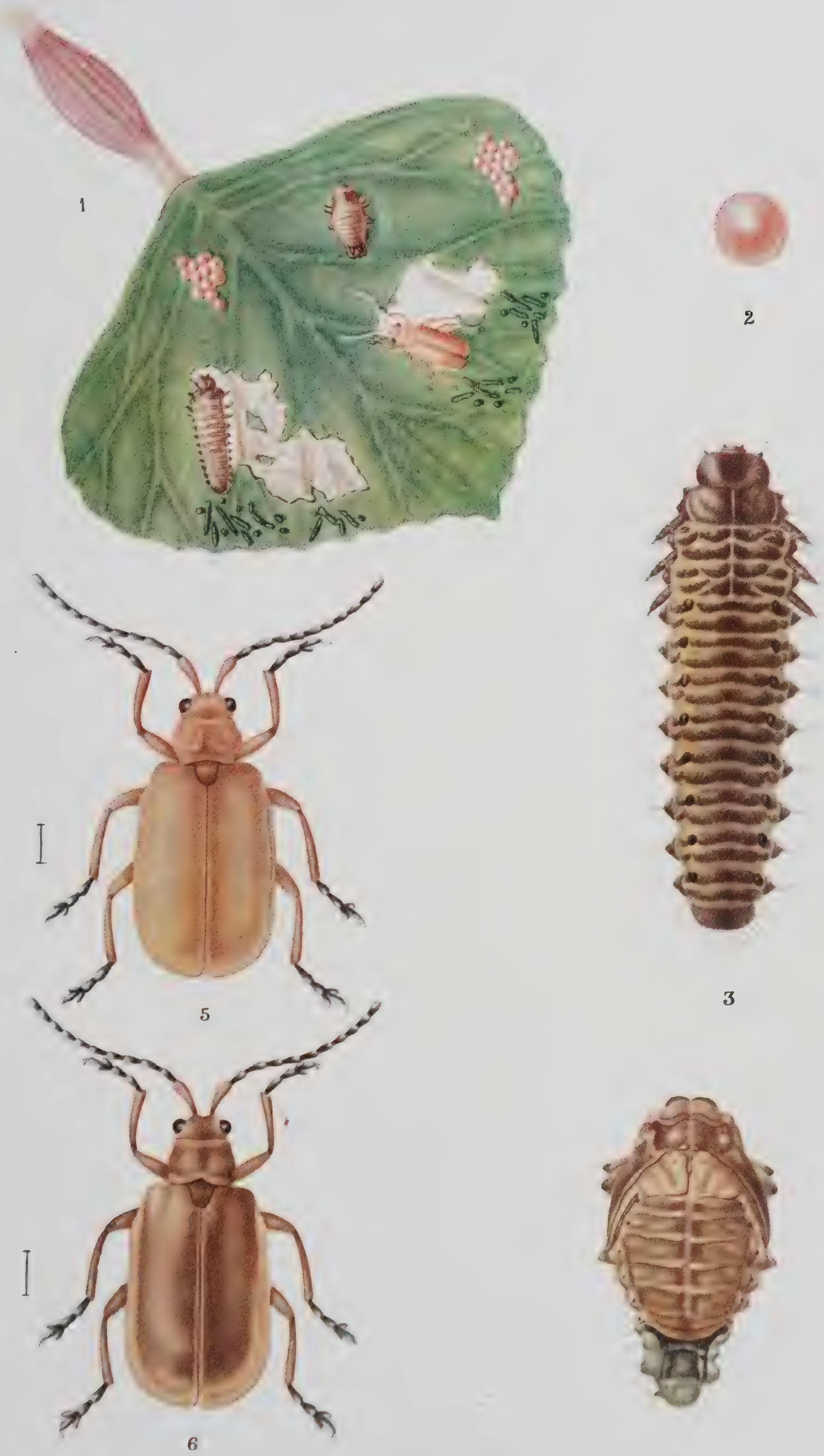
This beetle is a common pest to the Water-nut or Singhara plant (*Trapa bispinosa*) grown in the plains of India as a food-crop. The plant is aquatic, growing in tanks (ponds), the leaves floating on the surface. It is on these floating leaves that the beetle's life is passed, and the injury is caused to the leaves exclusively, both the larvæ and adults feeding on them.

EXPLANATION OF PLATE XV.

Galerucella singhara.

Fig. 1. Eggs, larva, pupa and beetle on leaf of Singhara. x 2.
,, 2. Egg. x 13.
,, 3. Larva, full-grown.
,, 4. Pupa, dorsal aspect.
,, 5. Male beetle.
,, 6. Female ,,

PLATE XV.



SINGHARA BEETLE.

Engraved and Printed
by The Calcutta Phototype Co

Life-History.—Eggs.—The eggs are laid in clusters on the upper surface of the floating leaves, each cluster consisting of 6 to 10 or 12 eggs, as many as sixteen being laid in one instance. Each egg is rounded, nearly smooth and unornamented, standing vertically on the surface of the leaf ; the eggs are not in actual contact, as a rule, but quite close together and are securely gummed down by the flattened base. The colour is a light tint of reddish brown (Plate XV, fig. 2). In captivity most were laid at night. Submergence of the eggs under water delayed hatching and one out of four died ; keeping the eggs in dry air resulted in all dying. They hatch normally on the floating leaf in seven or eight days. Before hatching the colour deepens a little and the egg becomes broader in proportion to its height, attaining a more perfectly spherical form. The egg can then be seen to be covered with minute "punctures" as the surface of the elytra of many beetles is.

The Larva.—Emergence from the egg is effected by the larva biting a semicircular aperture, forming a lid which it can push up. The egg-shell is not eaten. The larva is about 1 mm. long, almost black in colour, with a shiny black head. The thorax makes up nearly half the length of the body, the segments distinct ; there are two or three short hairs on each side. There are three pairs of short thick legs, terminating in a single long curved claw. The body tapers from the prothorax backwards, the abdominal segments short, distinct at the sides, each with three lateral hairs ; the eight segments are distinct, the anal segment small. The ventral surface of the body is yellow. The newly-emerged larva feeds on the epidermis of the leaf, biting out small pieces with its curved mandibles. The prothorax widens till it is broader than the head ; the black spots so distinct in the older larvæ appear on the second or third day, the skin between being yellow (Plate XV, fig. 3). In three days it has grown to a length of over 2 mm. and a breadth at the prothorax of over one and-a-half.

Moulting is effected by the larva fixing itself firmly by the legs and apex of the abdomen, the skin then bursting along the median dorsal line of the thorax ; the head is pushed out, the thorax and legs follow, and by wriggling the free anterior end

from right to left, the abdomen is slowly extricated. The process occupies an hour and-a-half. After this moult the colour is a little darker ; the small black ocelli are distinct ; the spiracles are seen to be small, round and depressed, with a hair in front of and behind each. The prothorax partly covers the head and each segment is divided transversely.

After the second moult the length has increased to 4 mm. ; there is little change at the moult. They are now able to eat out distinct cavities in the epidermis of the leaf in which they lie ; they do not even eat through the leaf, but feed wholly on the upper epidermis ; they are also able to swim from leaf to leaf if these are close together, so that as the larvæ hatched from a cluster of eggs eat up the leaf, they can move away to others.

The third is the last larval instar, the third moult giving rise to the pupa. The full-grown larva is 6 mm. long when at rest, 8 mm. when extended in movement. It crawls to a suitable spot above water-level, and pours a mass of gummy matter from the anus which fixes it securely ; the body then contracts and for four days the larva rests. The skin then opens along the mid-dorsal line and the pupa appears, the cast skin remaining at the posterior end. It hangs from the hind end, with the developing appendages tightly folded to it. Its appearance is shown in Plate XV, fig. 4. Submergence in water is fatal to the pupæ. Emergence from the pupa is effected by the splitting of the pupa case along the mid-dorsal line from the upper lip to the mesothorax ; the head of the beetle is pushed out, the rest slowly follows.

The Imago.—The beetles are shown in Plate XV, figs. 5, 6. The female is slightly larger and darker than the male. They live on the floating leaves, feeding on the epidermis. Flight has not been seen to occur, the beetle leaping agilely from leaf to leaf.

The following table shows the duration of the different stages :—

Eggs laid	11-XI	11-XI	11-XI	11-XI	11-XI
Eggs hatched	18-XI	18-XI	18-XI	21-XI	18-XI
Larvæ pupated	8-XII	11-XII	11-XII	13-XII	12—15-XII
Beetles emerged	17-XII	20-XII	20-XII	22-XII	21—24-XII
Total ...	36 days	39 days	39 days	41 days	40—43 days

In the fourth case above, the eggs were delayed two days by submergence in water and in the fifth case the larvæ were insufficiently fed. The periods are :

Egg	7—10 days.
Larva	20—27 „
Pupa	9—10 „

These were worked out in November when the cooler winter months have begun, and it is probable that period is lessened in hot weather. The actual dates of the larval moults are shown below :—

Egg hatched	18-XI	18-XI	18-XI
First moult	24-XI	24-XI	24-XI
Second „	28-XI	29-XI	29-XI
Third „	8-XII	11-XII	11-XII

The Singhara beetle is well known to those who cultivate this valuable plant as being a serious pest which they must check as much as possible. They do so by killing the eggs, larvæ and pupæ, but not all Singhara cultivators recognise all the stages of the insect. The beetle is active, leaping and flying readily when on the plants and is not at all easy to capture. As most of the work connected with Singhara is done in the water, the men floating on earthen pots, they are usually unable to capture the beetles. Constant destruction of the immature stages by hand is the only feasible remedy.

The pest is common in Bengal, Behar, the United Provinces, the Central Provinces and Gujarat. It probably occurs all over India where its food-plant grows.

Galerucella rugosa (Jac.).

The adults are found on the semi-aquatic weeds of the genus *Polygonum*, which grow by the banks of rivers. They feed upon the epidermis of the leaves from both sides, the leaf becoming white and membranous as the tissues are eaten away. They are active, the antennæ being in constant motion while they are feeding, and on the least alarm they jump off and fly away. All stages are passed on the leaf.

The eggs are laid in clusters, less than 24 hours after coupling has ceased. The female lays several clusters, at intervals

during several days after once coupling. The clusters are usually on the underside of the leaf, each consisting of from 20 to 50, rarely as many as 70 or 80 eggs. Each egg is round as seen from above, with a flat base, and tapering to the apex, where is a small black spot. The colour is yellow and the shell is ornamented with hexagonal ridges. The eggs are laid nearly touching one another ; the female bends down the tip of the abdomen as the egg is extended, the flat base sticking to the leaf; she then slowly raises the abdomen, extruding the egg which remains stuck to the leaf. She then moves a little and lays another and so on till the cluster is complete. (Plate XVI, fig. 1.) The eggs hatch in five to six days ; if removed from the plant, they must be kept moist as the leaf dries if plucked and the eggs dry up also.

The larva emerges by biting through the eggshell ; its appearance 48 hours after hatching is shown in Plate XVI, fig. 2. It has a black head, a divided black prothoracic plate, three pairs of black legs and an anal suckerfoot. The body colour is at first yellow, which deepens to orange as it grows older. There is little change as it grows older. The full-grown larva is shown in Plate XVI, fig. 3. The larva feeds on the epidermis of the leaf, moving only as it requires fresh food The larval life lasts for ten to twelve days, by which time the larva is full-fed and ready to pupate. Before pupation the larva emits from the anus a whitish gummy fluid which dries and forms a small white blotch. Into this the larva fixed the anal suckerfoot with its two hairs ; the head was then retracted, the larval skin ruptured and the pupa burst through, still held by the larval skin which envelopes the end of the abdomen.

The pupa is shown in Plate XVI, fig. 5 ; it is of the usual form, bright orange in colour, with lateral black processes. The pupa is usually found on the upper surface of the leaf and, if disturbed, agitates itself to and fro from the hind end. The pupal period is short, covering three to four days only. The whole life-history from the time of egg-laying to the emergence of the beetle is 18 to 22 days. In captivity they coupled two days after emergence, so that one brood might succeed another every 20 to 24 days under favourable circumstances.

EXPLANATION OF PLATE XVI.

Galerucella rugosa.

Fig. 1. Eggs on leaf. x 3.
,, 2. Larva ,, x 3.
,, 3. ,, 48 hours after hatching. x 20.
,, 4. ,, full-grown. x 6.
,, 5. Pupa. x 8.
,, 6. Female beetle. x 8.
,, 7. Male ,, x 8.

PLATE XVI.

GALERUCELLA RUGOSA.

The male and female are closely similar, the female a little darker. They are shown in Plate XVI, figs. 6 & 7. Pinned specimens become darker in colour.

APOMECYNA.

This genus is placed in Lacordaire's 37th group, *Apomecynides*, of the second division of the "Lamiides vrais" or *Lamiinæ*. The Munich catalogue lists four species, of which two are discussed here.

APOMECYNA PERTIGERA (Thoms.) (Phys. I, 6, p. 160).

The better known and larger species of this family are typically borers in hard woody tissues, as in forest trees; a small number of the less robust forms are known to live in herbaceous plants, but very little is known in India of the lives of such species.

The grubs of this species were found boring in the long trailing stems of the pumpkin (*Lagenaria vulgaris*), a plant extensively cultivated as a vegetable in India. No great amount of damage is done since the plant grows luxuriantly and the life of the insect is long, not admitting of great multiplication.

Life-History.—The eggs are laid by the beetle in the epidermis of the stem, usually at or near a node. Each egg is 1·5 mm. long, elongate oval in shape, with rounded ends (Plate XVII, fig. 1). The colour is a creamy white with a reddish tinge which disappears before hatching. As a rule, only one egg is laid at one place, but two were found in some cases. The egg opens first at the thicker end, splits longitudinally almost from end to end in two or three places, allowing the young grub to emerge.

Larva.—The egg hatches in five to six days; the young grub is about the length of the egg, cylindrical with the thorax, slightly larger than the abdomen which tapers to the hind end; the head is flattened, the segments distinctly marked; the colour is a creamy white, and there are minute hairs on each segment. Little change takes place during larval life; the prothorax remains large, the head small, flattened and of a brown colour; the prothorax is flattened and is chitinised above, giving it a dull brown colour; the segments behind are soft, distinctly separated; there are

distinct fleshy protuberances, which can be extended to exert pressure against the wall of the burrow, thus pushing the grub forward. Legs are absent. The full-grown grub measures 20 mm. : its appearance is shown in Plate XVII, fig. 2. On hatching, the grub bores into the stem and tunnels along it ; the tissues are eaten out as it moves along and a distinct tunnel formed. This tunnel extends along the central pith, the grub eating away the surrounding tissues. It is impossible to ascertain the moults as the larvæ are extremely sensitive to disturbance and are not easy to rear. When full-grown, a cavity is prepared which is closed behind with fibres and pieces of the tissues ; in some cases an incomplete fibrous cocoon is prepared as a lining to the cavity. No special provision is made for the exit of the imago. The pupa lies in the cavity, the cast larval skin behind it.

The pupa is shown in the Plate XVII, figs. 3, 4. It measures about 12 mm. ; motion is effected by the movements of the abdominal segments which have lateral projections and hairs.

The beetle emerges by biting its way out of the stem ; it feeds by biting into the softer parts of the trailing stems, or into the leaf petioles ; leaves are occasionally eaten, holes being eaten in them near the middle. Soon after emergence, the beetles mate ; during mating the female walks about and feeds, carrying the male. When disturbed, the beetles fall to the ground and feign death, the limbs folded tightly against the body.

The total length of the life-history is shown in the table :—

Eggs laid	12-V	17-V	18-V	18-V	20-V
Eggs hatch	17-V	23-V	24-V	24-V	25-V
Larva pupates	10-VI	19-VI	21-VI	27-VI	17-VI
Beetle emerges	16-VI	27-VI	27-VI	2-VIII	24-VI
Total ...	36 days	43 days	41 days	46 days	35 days

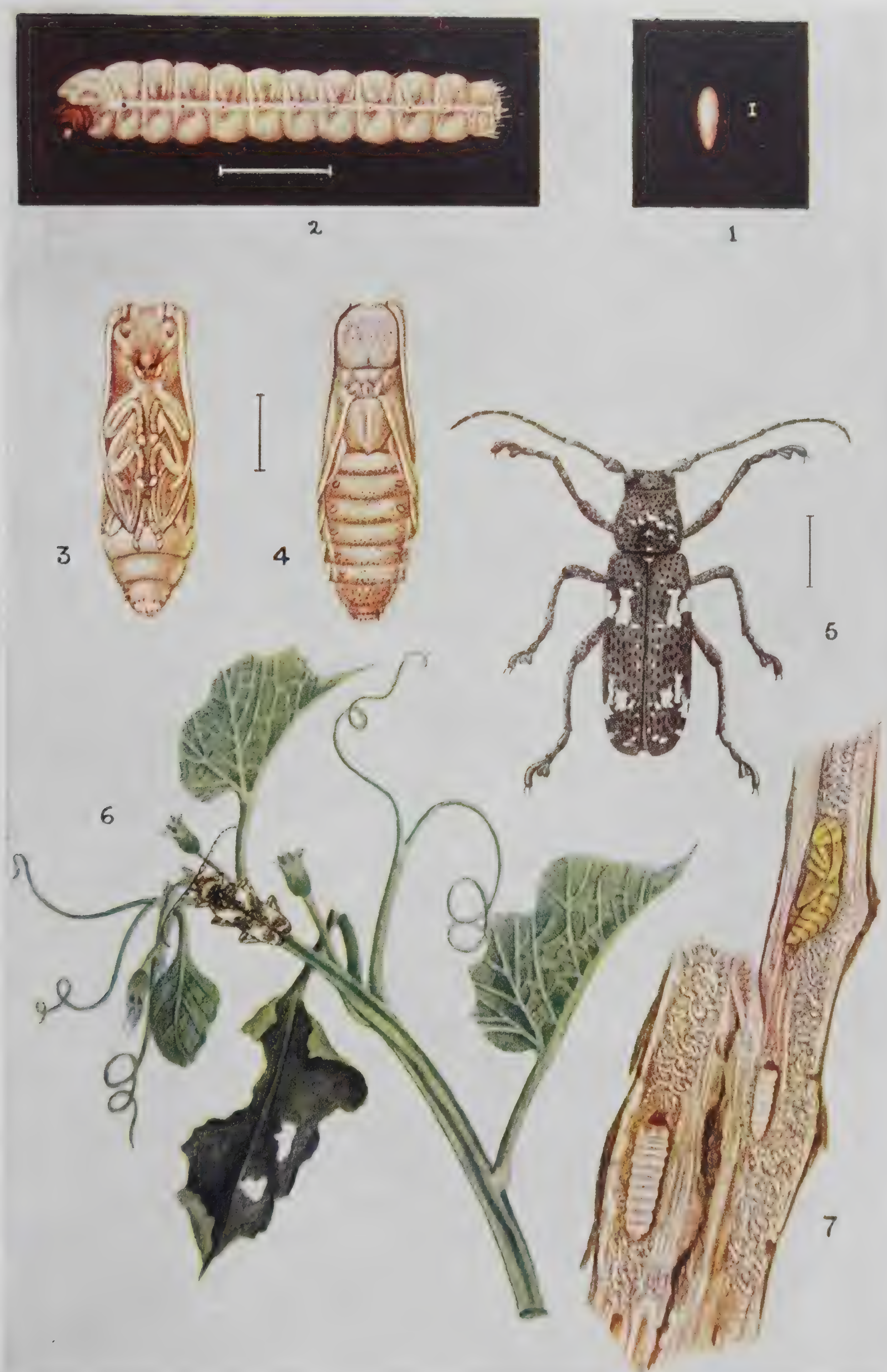
These periods are for hot weather. The larval period is very much longer in the cold weather, since the larvæ then rest in their burrows; larvæ collected on the 29th September remained as larvæ until the commencement of March, the first beetle emerging on March 12th. It has not been possible to find a definite sequence of regular broods in the year ; the length of the imaginal

EXPLANATION OF PLATE XVII.

Apomecyna pertigera.

Fig. 1. Egg.
,, 2. Larva, full-grown.
,, 3. Pupa, ventral aspect.
,, 4. ,, dorsal ,,
,, 5. Beetle.
,, 6. ,, feeding on growing plant.
,, 7. Larvæ and pupa in stem.

PLATE XVII.



APOMECYNA PERTIGERA.

life is the indefinite quantity, since they may pair and lay eggs soon after emergence or may wait for a considerable time. In the insectary, C. C. Ghosh was able to keep them alive as shown below.

Many emerged between the 10th April and 6th May; all but two died by May 31st; one died 3rd June, and the last on the 5th July, after a life of over two months—

One	emerged	30-VI;	died	2-VIII,	33	days.
,,	,,	27-VI;	,,	1-VIII,	35	,,
,,	,,	24-VI;	,,	2-VIII,	39	,,
,,	,,	2-VII;	,,	13-VII,	11	,,

Apomecyna histrio.

The larvæ were found boring in the stems of Gurrach, a wild creeper (*Tinospora cordifolia*).

They are whitish, thick, soft-bodied, elongate and subcylindrical. A full-grown larva is about 18 mm. long, 3 mm. broad. The head is small, hard, transverse and flattened, about twice as broad as long and partly retracted within the prothorax. It is of a reddish colour, the mouth-parts take a darker tint, the tips of the mandibles black. The mouth-parts are furnished with a pair of mandibles, stout and toothed in the inside. The prothorax is large and relatively broader than the other segments. It is protected on the upper surface with a hard plate and marked on the anterior margin by two large irregularly shaped yellowish patches. The meso- and meta-thorax are comparatively narrow, particularly the former, the body behind them becoming gradually narrowed. The last abdominal segment is short and truncate at the apex. The grub is footless, but the meta-thorax and the first seven abdominal segments, each bear above and below a short bulbous swelling, marked in the centre with a narrow transverse depression; the margin around the depression is raised and firmly tuberculated. These help the larva in moving along its burrow. They can be retracted within the segments and by pressing them against the sides of the burrow, the larva can propel itself forwards.

Nine pairs of spiracles are present, the first pair at the base of the prothorax, the remaining eight pairs are borne by the first

eight abdominal segments, a pair on each segment. The last segment is without any spiracles. The body is sparsely covered with scattered hairs, which are more closely arranged and form tufts on the last segment.

The larva feeds on the tissues of the stem, making irregular burrows in the course of its feeding. It pupates within the burrow after closing it at either end with a wad of closely packed fibres or tissues. Sometimes it covers itself completely above by a layer of tissues, but it does not form a complete cocoon.

The pupa is shorter and broader than the larva, with its abdomen gradually narrowing behind. It is about 15 mm. long. The head with the mouth-parts is bent well downwards on the thorax. The antennæ lie curled backwards on either side. The rudiments of the legs, wings and elytralie folded on the ventral surface and along the sides. The body is irregularly covered with hairs, but more thickly than that of the larva ; some of the abdominal segments bear on the dorsal surface irregularly scattered spines which are more conspicuous on the last two segments.

The pupa is whitish or pale yellowish, but just before the imago emerges the colour changes to pale brown. The pupal period lasts for about a week. When the imago first emerges, it is of a light brown colour with soft elytra. Gradually the colour changes to dark brown and the elytra harden.

The beetle is moderate-sized, measuring from 10—15 mm. in length and from $3\frac{1}{2}$—5 mm. in breadth. It is brown-coloured, densely pubescent above, less closely below and marked on the thorax and elytra with a number of oval or round white spots. The antennæ are stout and short, never reaching beyond the middle of the elytra and with the apical 5—6 joints black. The head is vertical or bent inwards on the thorax. The beetle closely resembles in colour, size and appearance, *A. pertigera*, but can be distinguished from that species by the nature of the white markings on the elytra. In *A. pertigera* the spots run into each other very closely and appear as a pair of large white irregular-shaped patches on each elytra, one a little below the base and the other midway between the apex and the middle. In *A. histrio* the spots do not run into

each other, and though they vary in number, the following appear to be fairly constant and can always be recognised. A pair of spots at the base of each elytron, an oblique row of 4 spots just behind these and a cluster of 4 spots between the middle and the apex.

Like many other species of the same family, *A. histrio* makes a sharp squeaking noise by rubbing the inner surface of the hind margin of the pronotum on a small, oval-shaped, smooth and highly polished raised surface on the mid-dorsal surface of the meso-notum.

Cylas formicarius, Fb.

The genus *Cylas*, with *Myrmacicelus*, forms the 33rd Tribe *Cylades* of *Curculionidæ* in Lacordaire's Genera Coleopterorum; eight species in all are listed in the Munich Catalogue, of which five are from Senegal, two from Java, and *C. formicarius* Fabr. from India. Two Indian species have been added, *C. submetallicus*, Desb., from Nagpur, and *C. impunctatus*, Fst., also from Nagpur. The Berlin Catalogue (1910) includes *Cylas* with the Apionides, enumerates 19 species and still retains *C. turcipennis* as distinct from *C. formicarius*.

Distribution.—In an article published in the Queensland Agricultural Journal, 1st August 1900, Henry Tryon gives a complete biography and an enumeration of the localities from which the pest is recorded. It is now known from Ceylon, India, Java, Queensland, Cochin China, Madagascar; it is common and destructive in most of the West Indian Islands, and in Florida, Texas and Louisiana. In India, it is apparently widely spread and occurs in every tract in which sweet potato is an important crop. There is apparently no record of its occurrence in Burma.

Origin.—The locality from which this insect was distributed is not now ascertainable; from the fact of its being first known from India, and first recorded as destructive in Ceylon, it has been supposed to have originated in India and to have been spread from there. Tryon points out that its definite record in Australia is quite recent (1886), while authors record its gradual extension during recent times in the United States. The fact that the

genus *Cylas* is, except for this species, still confined to India, Java and Africa would point to this species having spread from within this area. In view of its wide prevalence over India, the very small number of pests introduced to India and the small likelihood of sweet-potatoes being imported into India, where they are freely grown, except for special varieties introduced during recent years, we would regard *Cylas formicarius* as an insect native to India, Ceylon or Java and spread from there to other countries.

It will not be out of place to comment on the very great likelihood there is of this pest being spread to every country growing sweet-potatoes ; the stages are passed wholly in the potatoes ; the beetle lives for months without the necessity for reproducing and will then do so if food is available; and it would appear to be pre-eminently one likely to be carried to new countries with sweet-potatoes, which is always the form in which the plant is sent from country to country. We know of only one enemy to sweet-potato of equal status, the sweet-potato weevil of Barbadoes, *Cryptorhynchus batatæ*, Wat., which will also be likely to get a wide distribution if not checked ; but *Cylas* is a far more immediate danger since it has already so much wider a distribution.

Life-History. Eggs.—The female weevil, when ready to lay eggs, bites out a small hollow with her jaws, within which she deposits usually a single egg. The egg is creamy white, varies in shape a little, but is usually an elongate oval with round section and measures about $\frac{3}{4}$ mm. in length. They are laid both on the tubers and the thick stems or root-stocks of the growing plant ; they hatch in about four days.

The Larva.—The grub, on hatching, bores into the tissues on which the egg is laid ; it eats out a small tunnel which can be traced along the stem or tuber by the discolouration produced by the decaying tissues and by the excrement left behind by the grub. The newly hatched insect is legless, white in colour, about 1 mm. long ; the body is soft and the head has a yellowish tinge. The body is wrinkled and the rounded tubercular appearance of the segments is already distinct. There is very little apparent change as size increases ; the number of moults cannot be ascertained since

EXPLANATION OF PLATE XVIII.

CYLAS FORMICARIUS.

Fig. 1. Egg. x 10.

,, 2. Section of potato showing eggs laid in it and tunnels bored by young larvæ. x 2.

,, 3. Larva.

,, 4. Attacked potato.

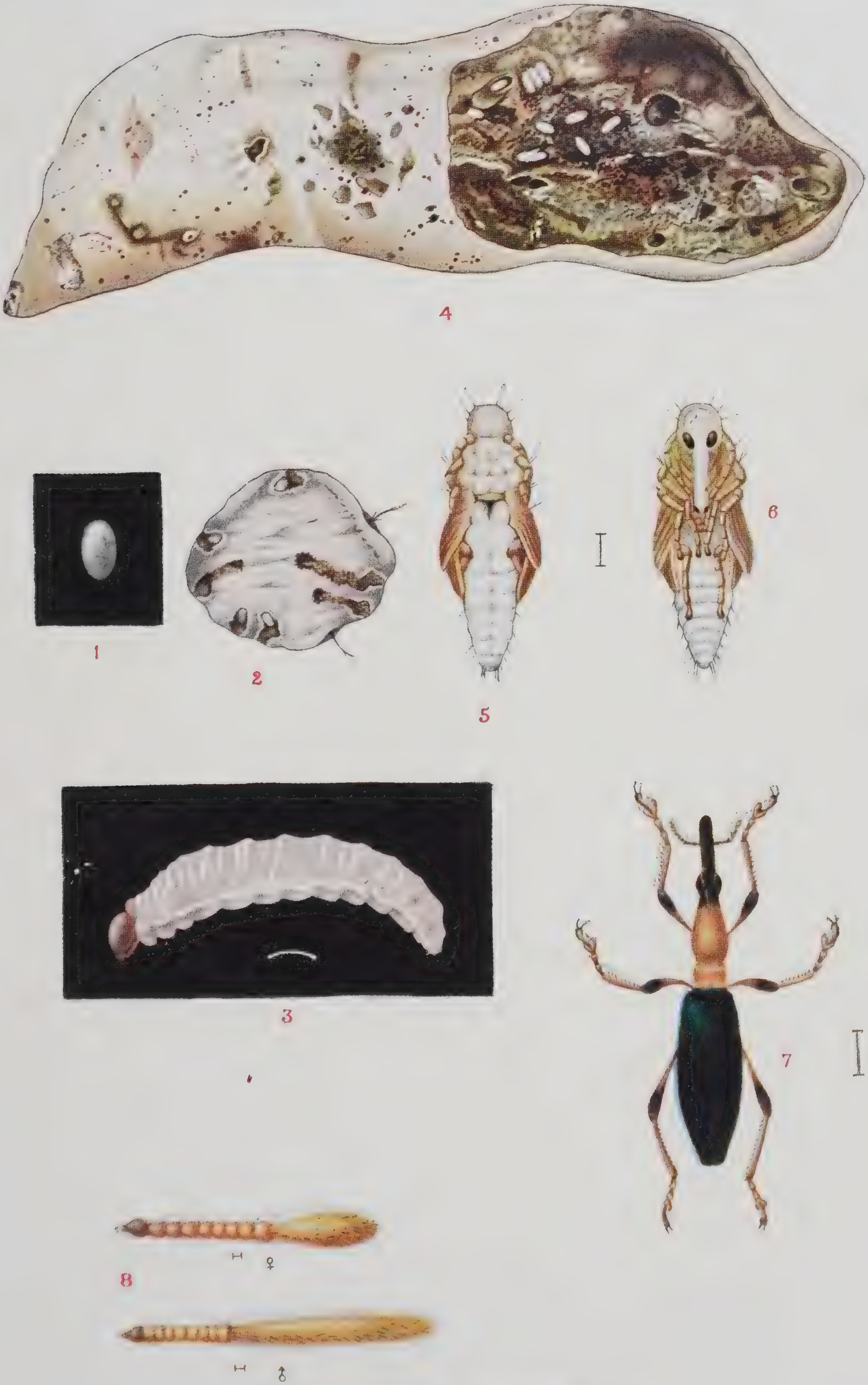
,, 5. Pupa, dorsal aspect.

,, 6. ,, ventral ,,

,, 7. Beetle.

,, 8. Antenna of beetle, female above, male below.

PLATE XVIII.



SWEET POTATO WEEVIL.

the larva is concealed throughout its life. The full-grown larva is 8 mm. long ; the head is small, pale yellow in colour ; there is a median dorsal suture ; the trophi are dark-brown or black. The dorsal surface of the prothorax is a faint yellow as if there were an indication of a prothoracic shield, as in Lepidoptera. The thoracic and abdominal segments are distinct, wrinkled and, between the wrinkles, there are soft rounded projections.

Larval Habits.—In the stems or rootstocks the larvæ bore straight along the middle towards the potato below ground ; a tunnel is eaten, growing larger as the larva increases in size, but not destroying the stem as is the case with other boring larvæ. Its object appears to be, not to find food there, so much as to reach the potato along the stem. In the potato, the larva makes a larger tunnel, extending apparently aimlessly in any direction but not piercing the rind. The tissues round the tunnel become discoloured, and, as a result presumably of "decay," the potato acquires a peculiar aromatic odour. The tissues are eaten in all directions and in extreme cases, every scrap is eaten until the interior is a mass of friable spongy matter, chiefly composed of excrement. Several hundred grubs will be found in one potato in an advanced stage.

The Pupa.—When full-grown, the larva eats out a rounded chamber, rests within it for one or two days, and pupates ; the head capsule bursts along the median suture and the pupa emerges. No covering is made and the pupa lies in the chamber with the cast skin. The pupa is white, from five to six millimetres long ; the disposition of the developing imaginal limbs is shown in Plate XVIII, figs. 5—6 The sex can be determined in the pupa, the female antennæ being longer and projecting beyond the femora. The apex of the abdomen terminates in two divergent hooked processes (Plate XVIII, figs. 5—6). These hooks assist the escape of the soft imago from the pupal skin ; the adult on emergence rests for two days prior to eating its way out of the pupal cell and the colour is even then not fully developed.

The Imago.—The sexes are readily determined from the antennæ, the males having the terminal joint longer and thicker

than the females. Wings are present and are used but rarely ; the weevils commonly run on the plants and have a curious trick of standing with the head upwards, the rostrum held straight out. They feed on the leaves or tubers, eating small holes in the leaves, making more extensive pits in the tubers ; in the latter case the pit has only a small opening but extends laterally inside, the long rostrum enabling it to eat out beneath the skin inside.

The following are three life cycles as determined in the insectary :—

Eggs laid.	Eggs hatched.	Larvæ pupated.	Weevils emerged.	Duration.
16-VII	20-VII	9-VIII	15-VIII	30
17-VII	21-VII	12-VIII	17-VIII	31
18-VIII	22-VIII	9-IX	15-IX	28

Hibernation, etc.—There are apparently only two habitats in which this insect can be found ; it is either breeding in the growing plant or in the sweet-potato, in which case it is found in all stages ; or the adult is found waiting over until it can reproduce. Sweet-potato is to some extent a continuous crop since it is planted from cuttings, and there will either be a crop or there will be a small area kept to supply cuttings for the next crop ; the weevil will probably then not have long to wait between the harvesting of one crop and the growth of either another crop or a small area for seed ; the weevil can, however, live long periods without breeding or dying ; in the insectary, with tubers for food, they lived for from one to over three months ; it is probable that under more natural conditions they would live longer. They can be found sheltering especially in thick grass, such as dense doab grass (*Cynodon dactylon*), which grows by roads and on headlands. We have found them at all times of the year in this way, and when there is a growing crop of sweet-potato, they will be found walking in their peculiar way or standing with extended rostrum on the leaves of the plant. Periods of cold are apparently spent in hiding as an imago, but the larvæ and pupæ survive the ordinary cold of Behar if in potatoes, their development apparently being checked.

This insect is one that has no regular fixed seasons, so far as one can see, in the sense that so many other insects have, because its food-plant occurs irregularly and almost all through the year.

Damage.—The insect is injurious to the sweet-potatoes both before and after they are dug from the soil ; it is apparently not injurious to the growing plant, the small tunnel of the larva in the stem not injuring the plant appreciably. When the crop is dug, it is found that the potatoes are infested and everyone in that condition must be destroyed or immediately used. When once the insect has obtained access, breeding continues inside and a sweet-potato once affected cannot be rid of its inhabitants ; they come to maturity, couple and lay eggs in the potato and the imago does not necessarily emerge from it at all.

We have no data for estimating the loss caused by this insect in India. In no single case have we found a sweet-potato crop unaffected, but in many cases the percentage of loss has been extremely small. In other cases, we have seen a field covered with rejected spoilt potatoes from which all not absolutely destroyed had been removed and a rough estimate of immediate loss has been a quarter, with certainly more than half the potatoes infested and only fit for immediate consumption. Sweet-potato is an important food crop in India and there is an appreciable percentage loss probably from this pest.

Prevention.—The best preventive is to keep the potatoes well covered in soil, so that egg-laying cannot take place in them direct ; where the soil cracks on drying, exposing the potatoes, or where the potatoes are not deep enough, the weevils get access to them direct and there is direct infection. The second and obvious precaution is the immediate and thorough destruction of all infested potatoes as soon as the crop is dug ; it is a common custom to leave the worst potatoes on the field as not worth the trouble of taking away, with the result that breeding continues steadily and, so long as there is a shred of tissue left, the grubs can feed and complete their development ; it has been proved that moderately infested potatoes, boiled, can be fed to stock in small quantities ; heavily infested potatoes should be burnt or deeply buried.

CIONUS HORTULANUS (Fourc.), var *major*.

The genera *Cionus* and *Nanophyes* form Lacordaire's "Tribu LI" Cionides of the Curculionidæ. The Munich catalogue lists a number of species from Europe, Africa, Tasmania, etc., none from India. *Cionus hortulanus* (Fourc.) (Ent. par. i, p. 129) is given in the Munich catalogue as a synonym of *C. similis*, and is recorded from Europe and Western Persia. It probably also includes Faust's *C. dependens*, found by Stoliczka in North India with which it closely agrees.

Among the common weeds of Pusa, the yellow flowering *Celsia coromandeliana* * can be found, especially on the sites of the ruined buildings that have been dismantled. On this plant the weevil here described passes its life-history ; weevils are common insects, but it is rarely that one finds them in the larval stage ; rarer still is it to find what one supposes may be a caterpillar prove to be the larva of a weevil. The habits of the family are so diverse that no generalities are possible except perhaps that they are mainly vegetable feeders and commonly in or on living plants. The few whose larval habits are known in India seem to be all borers in some part of a plant, as the mango weevil, the cotton stem weevil, sweet-potato weevil, the palm weevil, etc.

In the present case we have a life-history approximating to that of the Lepidoptera, the period short, the larva formed like a caterpillar, the pupa in a case fixed to the plant. The larva has the form common to many caterpillars, the cylindrical body, tapering to the head and tail, which appears thickset and short when contracted, slender and graceful when stretched to its fullest extent. The segments are clearly marked by ridges and indentations ; one continuous indentation runs lengthwise along each side ; below this line are the short rounded lobes, characteristic of Curculionid larvæ, the lower ones serving as feet, the upper ones provided each with short bristles which probably assist locomotion. The body is completely covered in gummy matter and has a smooth shining appearance ; the skin is clear, the general colour an indefinite brown produced by the semi-transparency of the internal organs. Leg

* Kindly determined by A. Gage, Esq., Royal Botanic Gardens, Calcutta.

EXPLANATION OF PLATE XIX.

Cionus Hortulanus *var.* Major.

Fig. 1. The food plant, *Celsia coromandeliana*, with the larva, cocoon and weevil. x 2.

,, 2. The cocoon after the weevil has emerged. x 2.

,, 3. & ,, 4. The weevil. x 10.

PLATE XIX.

CIONUS HORTULANUS.

Engraved and Printed
by The Calcutta Phototype Co.

and suckerfeet are absent, locomotion being effected by the ventral lobes and the contractions of the body ; the gum evidently assists in this process, the short dense hairs of the food-plant sticking to the gum, and, as it were, holding the little creature down. The total length does not exceed one-quarter of an inch. The head is very smooth, of an intense black above ; on the upper surface of the prothorax is a tiny black plate, divided in the middle, similar to the prothoracic shield of caterpillars. Nine pairs of spiracles are present, on the third thoracic and the abdominal segments. The mouth-parts are the small biting jaws of the beetle larvæ, similar in general form to those of caterpillars. The food consists of the flower buds and developing fruits, the larva biting through the outer tissues and feeding within. Only the slender head and neck are inserted in the fruit, the gummy body clinging to the plant. The larvæ move little on the plant, going in search of fresh food as it becomes necessary. The two broods under observation have appeared only on a few plants, the first only on one, the second on plants close by. Since then broods have been obtained in captivity in the open fields and the whole life-history is completed normally in suitable cages.

The pupa lies in a round case, which is horny in appearance and translucent. The case is oval, neatly rounded at the ends, almost smooth. Within, one may dimly see the larva or pupa and it is easy to watch the full-grown larva preparing its covering from within. The case is made of a clear gummy material, white and mucilaginous, which is produced from the anus. The actual preparation of the wall is done by the mouth-parts and the front of the head ; the larva takes a large drop of this gum from the anus, and plasters it down, the flat part of the front of the head holding the drop in place, the jaws working and spreading the material evenly. The process is incapable of description ; one can only say that all the parts of the mouth are utilised, the mandibles and maxillæ with a lateral action, the lower lip with an up and down movement, the result of the harmonious motion of every part being the smooth even application of the material not only over the part that is already firm but beyond the edge, carrying the wall each

time a little further round in its perfect curve till the whole is complete. Many drops are needed to do this and the larva lies curled up with the anus within handy reach of the mouth. Possibly a mathematician would see that the oval shape is a natural result of the position and proportions of the larva ; that would certainly seem likely, the final shape of the case being perhaps the limits of the space within reach of the larva and is the natural form that is inevitably given to the case by a creature of that size, lying in that position. The gummy matter in a few minutes becomes opaque, hardens and turns horn colour. These little cases are fixed to the plant, to a bud or leaf usually and remain for some twelve days ; then one end breaks, not irregularly but in a clear straight line that cuts off the end of the case and allows the beetle to emerge. Whatever be the cause of this device, one cannot but admire it ; possibly it is to be attributed to the art of the larva who made the case and allowed for it beforehand by leaving a line of weakness in the wall ; possibly it is the weevil who, instead of trying to push or eat through anyhow, comes out neatly and properly by cutting round the end with his beak.

The weevil is globular almost, with a rounded abdomen and thorax, the prothorax slim and tapering, the head narrow and continued into a slender beak. The legs are long, with thickened thighs ; the antennæ, elbowed and clubbed, set midway on the straight slender beak. The hard skin is actually black or nearly so, but a fine brown yellow down gives a greyish appearance, relieved by many black spots where the down is absent. One larger black spot lies in the middle of the wing covers, and other smaller ones lie on flat ridges which run down the elytra. The general appearance is a greyish brown insect with neat black spots and brown legs. The amount of grey varies, in some a warm reddish brown predominating. The sexes are alike in size and appearance. Beneath the wing covers is a pair of large dark wings folded away and rarely used.

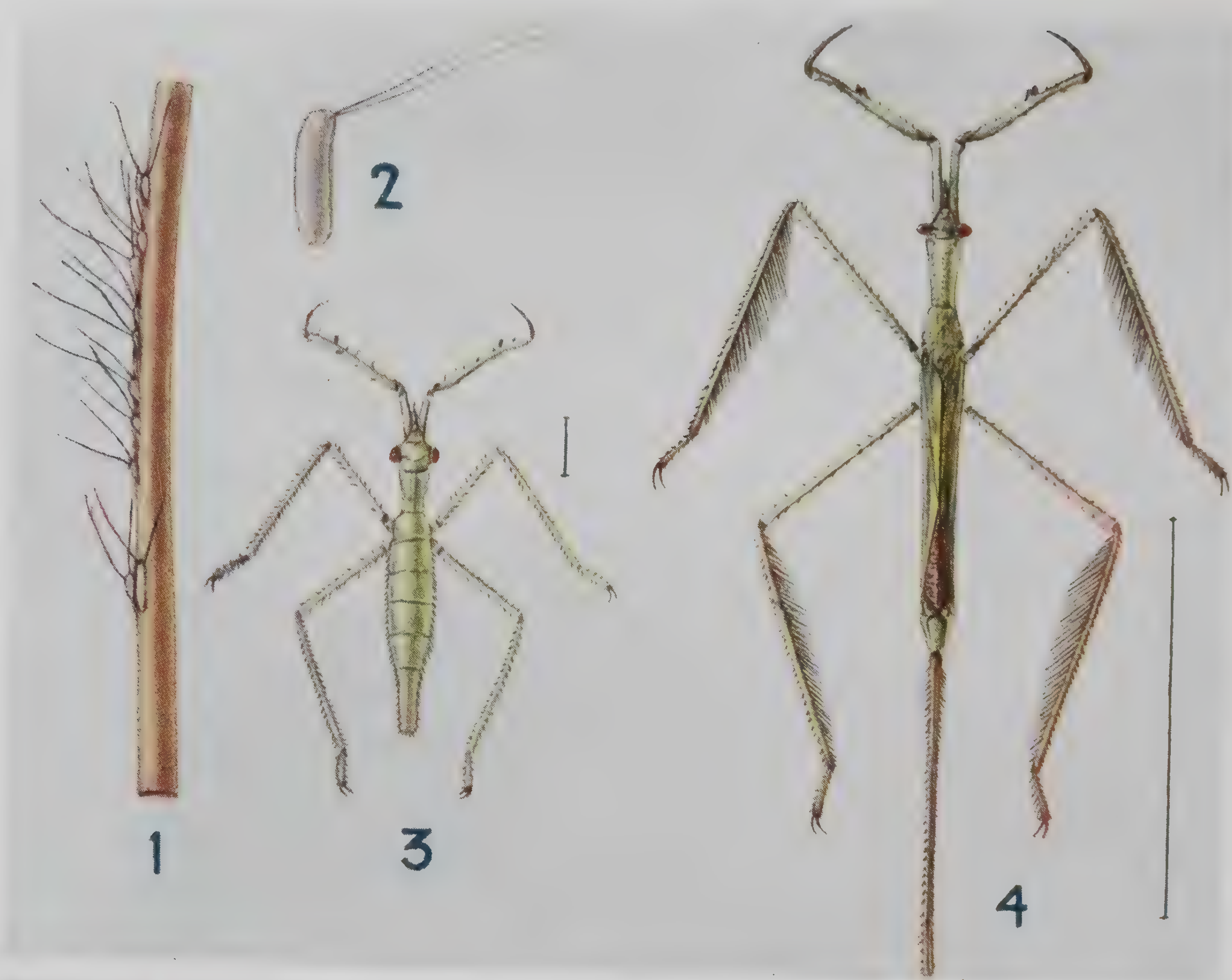
On the plant one scarcely sees the little weevils, which sit motionless probing with their beaks in the flower buds or developing fruits ; the slender beak enables them to eat into the flower

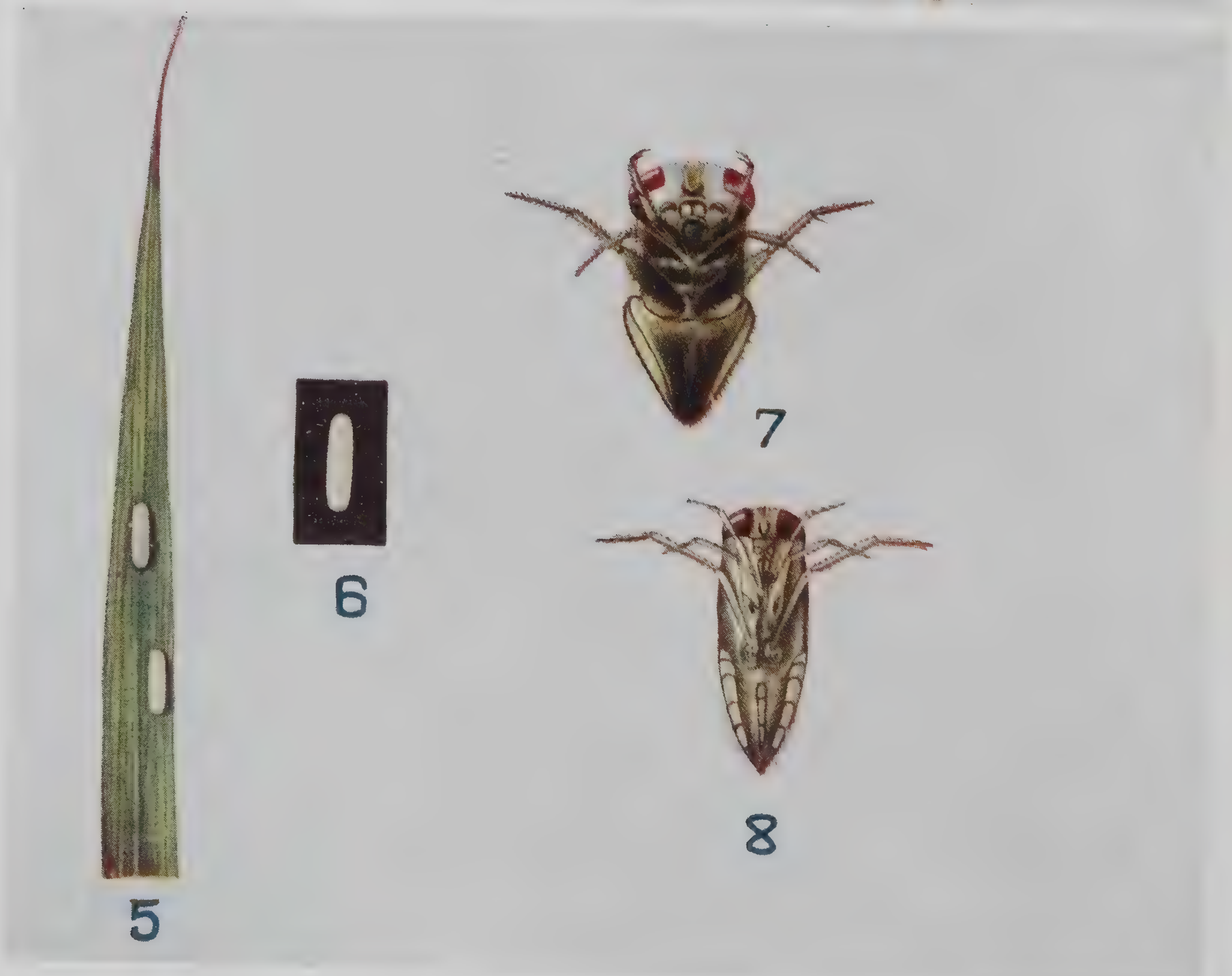
buds much as the larva did, and if these fail, they feed upon the stems of the plant. Eggs were obtained from the weevil without difficulty in captivity, many small oval eggs being laid on the plant. Each egg is oval, longer than broad, of a bright yellow colour ; they are fastened to the plant by the side, each singly, on different shoots. About one month is occupied in the whole life-history ; the egg hatches in about a week, the larva feeds for about a week, the pupa takes twelve days, and the imagos, when plentiful, couple and lay eggs in from three days to a week.

This species is, in Pusa, a regular "cold-weather" species, breeding from February onwards to April, while its food-plant is available. It then hides away as a weevil, and remains alive in hiding until the following January. It is an extremely good example of that large class of insects, probably all migrants from the Himalayas, which breed and are active during the cold season and then "æstivate" in the imago form till cold comes again.

We have had *Cionus* yearly from February to April ; in Mussoorie at 7,000 feet elevation, it breeds during the summer months and there is little doubt that, like others of its class, it has migrated down into the plains and has in this way adapted itself to the altered climatic conditions.

PLATE XX.





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EXPLANATION OF PLATE XX.

Ranatra filiformis

(1). Part of a stem with the eggs in the natural position.
(2). Single egg.
(3). Nymph.
(4). Imago.

Enithares indica.

(5). Portion of a blade of grass with the eggs in the natural position.
(6) Single egg.
(7). Nymph.
(8). Imago.

LIFE-HISTORIES OF INDIAN INSECTS—II.

SOME AQUATIC RHYNCHOTA AND COLEOPTERA.

BY

D. NOWROJEE, B.A.,

Assistant to the Imperial Entomologist.

RANATRA FILIFORMIS, Fab.

THE genus *Ranatra* belongs to the family *Nepidæ*, characterised by the long apical filiform appendages. Two species of *Ranatra* are found in Pusa, *R. filiformis*, F., and *R. elongata*, F. The former, which is much the shorter, about half the size of the latter, is also the commoner one found throughout the year.

The Egg:—The eggs of *R. filiformis*, F., are whitish, smooth, elongate, cylindrical with rounded ends, and slightly curved at the anterior end. They are about 2¼ mm. long and ¾ mm. broad. From the anterior end a little below the apex is given off a pair of long thread-like filaments about 4 mm. long. The eggs are laid in oblique slits made in the stems of aquatic weeds (Plate XX, Fig. 1); in some cases the whole of the egg lies buried in the tissue of the stem, only the filaments projecting out; in others only a portion of the egg is embedded in the tissue, the remainder with the filaments lying free out of the slit. The eggs are laid irregularly along the stem which lies submerged under water. Eggs found on the 13th March hatched on the 17th and the 19th. The nymph escapes through a small crescent-shaped opening which it makes at the upper end of the egg just below the base of the filaments.

Nymph:—The nymph, when just hatched, is dark brown coloured, the body elongate and narrow, about 5½ mm. long and

two-thirds of a mm. broad. The head is triangular, produced anteriorly into a short sharply-pointed beak. The eyes are large, round and prominent. Three pairs of legs are present; the anterior pair slightly thickened, the posterior two pairs long and slender, about $1\frac{1}{2}$ times as long as the anterior. The last abdominal segment is produced at the apex into a short tube-like process open at the tip which serves the purpose of respiration. The nymphs were fed on the larvæ of *Anopheles*. The prey is seized by the anterior pair of legs for which purpose they are very well adapted: the anterior third of the femora is curved outwardly, the tibia is curved inwardly as shown in the accompanying diagram (Fig. 1), so that when the latter is folded on the former, they form a pair of strong claspers capable of holding a struggling prey in a firm grip. When an *Anopheles* larva comes within reach, one of the anterior pair of legs is quickly shot out and the victim seized and slowly transferred to the mouth where it is transfixed on the beak; the forearm is then dropped and the juices slowly sucked out of the victim; if, however, the larva keeps wriggling, the arm is brought up again to hold it until enough has been sucked out and the larva becomes flabby and ceases to make any efforts to escape. The forearm is then quietly dropped so that it is free to grasp another larva, should it come within reach. A *Ranatra* can thus often be observed with one larva transfixed on the beak and another grasped in either forearm.

Fig. 1: anterior leg of R. filiformis a. closed, b. opened.

Life-history:—The nymph, as it grows, moults. Just before a moult the skin splits along the mid-dorsal line from the base of the head to the last thoracic or the first abdominal segment and is shed by the nymph.

The accompanying tables show the duration of the life-history :—

EGGS FOUND ON 13th March.

Egg hatched	First Moult.	Second Moult.	Third Moult.	Fourth Moult.	Fifth Moult.
17-III. Length of the body 5½ mm. Length of Respiratory tube 1 mm.	23-III. Length of the body 7 mm. Length of Respiratory tube 2 mm.	28-III. Length of the body 11 mm. Length of Respiratory tube 4 mm.	3-IV. Length of the body 16 mm. Length of Respiratory tube 6 mm.	9-IV. Length of the body 21 mm. Length of Respiratory tube 9 mm.	20-IV. Length of the body 26 mm. Length of Respiratory tube 23 mm.
19-III.	27-III.	1-IV.	6-IV.	13-IV.	22-IV.

The complete life-history from egg to imago thus occupies about 34 days. Each of the first four instars lasts on an average for about 5 days, while the interval between the fourth and the fifth or the last moult is about 10 days. The growth in the respiratory tube is fairly equal for the first four moults, being from about 2 to 3 mm. ; in the last moult, however, the respiratory tube more than doubles itself in length.

The Imago :—R. filiformis, F. (Plate XX, Fig. 4), when full-grown, is about 25 mm. long excluding the abdominal appendage, and about 2 mm. broad ; the abdominal appendage is about 23 mm. long. The body is narrow and elongate, of a dull brown ochraceous colour. *R. filiformis*, F., is abundant during the cold weather in the river where it lives near the banks lurking among aquatic weeds. Eggs and nymphs are abundant during March and April. Nymphs have also been found, though rarely, in ponds during the rains, and it is probable that breeding is continuous throughout the hot weather and the rains.

R. filiformis is a poor swimmer, usually remaining under water, crawling amongst the weeds except when it creeps to the surface from time to time to breathe. Respiration is carried on by means of the long abdominal appendage. It consists of a pair of long processes, each grooved on its inner side ; by bringing the two halves together, a complete tube is formed which is open at the apical end ; the tube leads to the terminal pair of spiracles situated at the apex of the abdomen on the ventral surface. When *Ranatra* wants to breathe, it creeps backwards along the sub-

merged weeds until the tip of the abdominal appendage rests above the surface of water, and air is then carried along the respiratory tube to the spiracles.

ENITHARES INDICA, Fab.

The genus *Enithares* is placed by W. L. Distant in the sub-family *Notonectinæ* of the family *Notonectidæ*. It is common during the rains in ponds and pits filled with more or less stagnant water. The insects belonging to this family can easily be distinguished in their natural habitat by their characteristic habit of swimming on their backs.

The Egg :—Enithares indica, Fab., lays its eggs on the stems and leaves of aquatic plants, either floating on the surface or submerged below water. The eggs are laid openly on the surface of the stem or leaf and not inserted within the tissue (Plate XX, Fig. 5). They are laid lengthwise on their sides and glued to the surface by some secretion which the female doubtless exudes. One female kept in an aquarium laid in all 8 eggs, but it is probable that the number of eggs laid by a single female varies much. The eggs are smooth, whitish, elongate, and cylindrical with rounded ends, about $1\frac{1}{2}$ mm. long and $\frac{1}{2}$ mm. broad. The eggs take from about 9 to 11 days in hatching :

Eggs laid on the night of the 10th September.				
One egg hatched on the 19th September.				
Two eggs	,,	,,	20th	,,
Three ,,	,,	,,	21st	,,

The colour of the egg gradually changes from whitish to brownish-black. Just before the nymph emerges, two crimson spots which mark the position of the eyes of the nymph appear at the upper end of the egg and the segments of the thorax and abdomen can be indistinctly seen through the egg-shell.

Nymph :—The nymph (Plate XX, Fig. 7) is broadly oval with the upper surface convex and the lower one more or less flattened, and just after emergence is about 2 mm. long and 1 mm.

broad. The eyes are large, crimson coloured; three pairs of thoracic legs are present, the anterior two pairs comparatively short, the posterior pair very long and fringed with hairs. The nymphs were fed on small insects which were grasped by the anterior pair of legs, the beak inserted into the tissues and the juices slowly sucked out. The nymphs, as they grow, moult; the skin splits mid-dorsally along the thoracic segments and is shed by the newly formed nymph.

The table below gives the duration of the life-history—

Egg laid.	Egg hatched.	1st Moult.	2nd Moult.	3rd Moult.	4th Moult.	5th Moult.
10th Sep.	20th Sep.	26th Sep.	1st Oct.	7th Oct.	14th Oct.	23rd Oct.
,, ,,	21st Sep.	27th Sep.	3rd Oct.	10th Oct.	16th Oct.	27th Oct.
,, ,,	,, ,,	29th Sep.	5th Oct.	11th Oct.	17th Oct.	29th Oct.

The life-history thus occupies from the egg stage to imago from about 30 to 38 days. Each of the first four instars lasts on an average for about 6 days, but between the fourth and the fifth or the last moult there is an interval of from 10 to 12 days.

The Imago:—*E. indica*, Fab. (Plate XX, Fig. 8), when fully developed, is about 9 mm. long and about one-third as broad as long. As has been said above, the characteristic feature of the family is their habit of swimming on their backs. The posterior pair of legs are long and have the tibia and tarsus fringed with long hairs and form efficient organs of locomotion by means of which the insect is enabled to swim swiftly through the water and also make sudden leaps when disturbed. When remaining below the surface, it clings by the anterior pair of legs to submerged weeds; as it is lighter than water and very buoyant, it cannot remain for any length of time under water without clinging to some object but rises quickly to the surface as soon as it lets go its hold; occasionally it can be observed to remain suspended in midwater without any support, retaining its position by rapid vibrations of the hind legs. *E. indica* is predaceous on small aquatic insects; it also feeds on other dead or living insects which are blown into the water and keep floating on the surface. It is common in the

khajanas or masonry water tanks in indigo factories; it has a curious habit of resting a little distance below the surface, getting its air-supply in sudden quick jerks to the surface and then descending; the habit suggests danger from the surface but safety at a little distance down, but what enemy there is at the surface, unless it be *Hydrometridae*, is not known.

EUNECTES (ERETES) STICTICUS, L.

The genus *Eunectes* is represented in India by only one species, *E. sticticus*, L., which can be distinguished by the peculiar serration of the edges of the elytra from the middle to the apex. The Pusa collection contains specimens from Bengal: Pusa, Chapra; Bombay: Karachi, Igatpuri (2,000 ft.); Burma: Monywa; and the species is probably found throughout India, being one of the commonest of the *Dytiscidæ*.

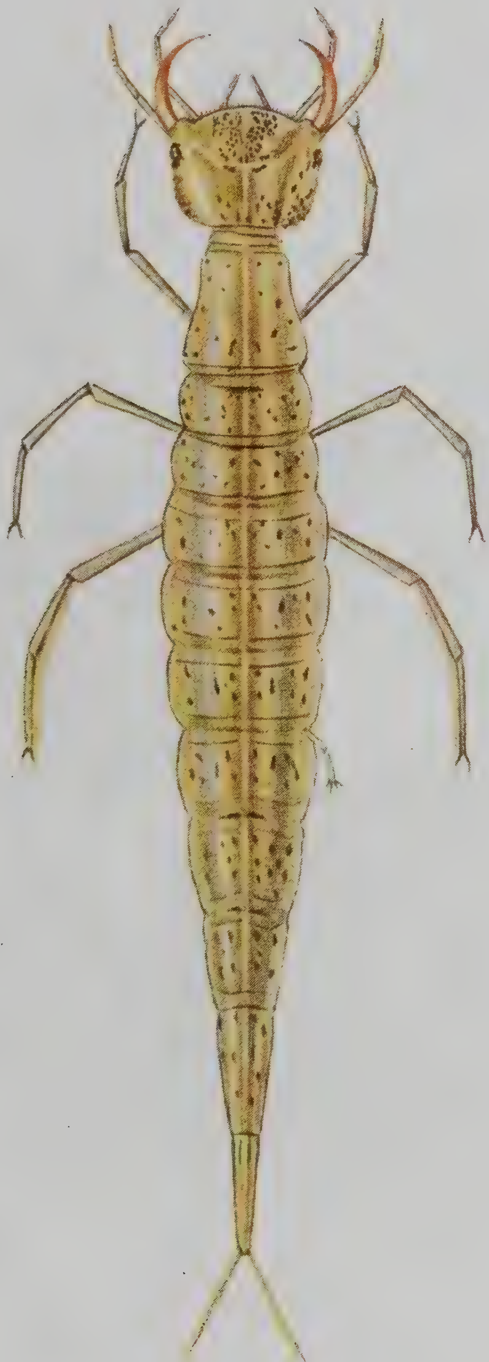
Larva :—The larvæ were found in the drains around the Pusa College, in the jute pits and ponds. They were first observed at the beginning of the hot weather and were present throughout the hot weather and the rains up to about the end of October. The larva (Plate XXI, Fig.1) is elongate, spindle-shaped, being broadest a little below the middle and gradually narrowing towards either end, and is, when full-grown, about 26 mm. long and 3 mm. broad. The head is pale brown coloured, large, longer than broad and flattened above; it is narrowed posteriorly and joins with the prothorax by means of small but distinct neck. The mandibles are long, slender, curved and finely pointed at the apex. Near the base of the mandibles is given off a pair of short three-jointed antennæ. A pair of eyes is present, each formed of a number of ocelli. The prothorax is long with the sides narrowed anteriorly, the meso- and meta-thorax are comparatively shorter and broader than the prothorax. The penultimate abdominal segment is elongate and narrow, the last much more so and tapering apically to a blunt point. The integument is hardened on the dorsal surface and forms a series of hard plates, one on each segment, which protect the body above and at the sides; the under-surface of the body

EXPLANATION OF PLATE XXI.

Eunectes (Eretes) sticticus.

(1) Full-grown larva, dorsal view.
(2). Imago.
(3). Pupa, ventral view.

PLATE XXI



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remains soft except for the last two segments which are completely enclosed in a hard sheath. From near the apex on the ventral surface is given off a pair of stiff processes. The usual three pairs of jointed thoracic legs are present, each ending in a pair of claws and thickly fringed with hairs. The last two segments are provided at the sides with a broad fringe of hairs. The larva is grey-coloured above and whitish below except for the last two segments which are entirely grey.

The larva can swim well; its usual pace is a slow and leisurely one and is effected solely by the movements of the three pairs of thoracic legs, but it also makes sudden darts particularly when annoyed or disturbed. The movement is so quick that the eye can scarcely follow it and is carried out by a jerking movement of the body, the larva bending it and suddenly straightening it out again.

Seven pairs of spiracles are present, the first pair at the base of the prothorax and the remaining six pairs, one pair on each of the first six abdominal segments; but these spiracles are not functional. Respiration is carried on by means of the terminal pair of spiracles situated at the tip of the body; the larva, when it wants to take in air, slowly rises to the surface, tail-end upwards, its body thrown into a gentle curve till its tip is on a level with the surface of the water and the spiracles exposed to the air; these spiracles lead to the main pair of longitudinal air tubes which appear through the integument when the larva is observed from the dorsal surface as a pair of indistinct dark longitudinal stripes one on either side; when a sufficient supply of air has been taken in, the larva slowly sinks below, repeating the same process again at varying intervals.

The larvæ are predaceous, feeding on live prey; in the aquarium in the laboratory they were fed on larvæ of dragonflies and other small insects; when its prey comes within reach, the larva with a quick turn seizes it in its mandibles. I have not observed the legs being used in seizing the prey. The larva feeds by thrusting the points of the mandibles into the tissues and slowly sucking the juices out of the victim. From an examination, however, of

the insects which had been sucked out, it is probable that the larva not only sucks the juices but also devours a portion of the solid tissues; these were seen to have been eaten in some cases, leaving only the hard outer integument. In the case of *Cybister tripunctatus*, Ol, a larva of which was fed on small shrimps, shortly after the larva had seized a shrimp, it was observed to inject a dark-coloured fluid into its body; the fluid was injected two or three times and probably served to dissolve the tissues of the shrimp.

The larvæ are very ferocious, constantly attacking and preying on one another. A larva, when seizing another, usually grasps it just below the head, its weakest point, as the latter is then at a disadvantage, not being able to use its mandibles and can only wriggle about helplessly in the jaw of its enemy.

Pupa:—When full-grown the larva leaves the water and burrows into the mud where it makes a round hole smooth in the inside within which it lies; it remains in the larval stage for about a couple of days when the skin splits along the mid-dorsal line from the base of the head to the third or fourth abdominal segment and lies at the apical end of the pupa. The pupa (Plate XXI, Fig. 3) is whitish, oval-shaped, shorter and broader than the larva, about 13 mm. long and 5 mm. broad. The head is large, smooth, round, and with the mouth parts is bent down on the thorax. The prothorax is large, broad, with the sides slightly rounded; the anterior margin concave, the posterior nearly straight. The disc is strongly convex and furnished with a number of spines placed as follows: a row of spines along the anterior margin, a pair on the middle of the disc and a few closely placed at either posterior angle and at the middle of the posterior margin. The meso- and metathorax are shorter than the prothorax and furnished each on the mid-dorsal line with a row of short spines. The abdomen gradually narrows posteriorly; the last segment is small and is produced at the apex into a pair of short stout processes, each tipped with a number of minute spines. The pupa bears in addition a few small spines on the dorsal surface of the abdomen. The rudiments of the wings, elytra and legs of the future imago lie folded

on the ventral surface and at the sides. The pupal period is very short, lasting for about six days ; larvæ which entered the soil to pupate on 18th May, pupated on 20th May and emerged as imagines on 26th May. The imago, when just emerged, has the body pale-coloured and the elytra soft ; the latter gradually harden and the colour takes on a deeper shade.

Eunectes sticticus, L. (Plate XXI, Fig. 2) is olive brown-coloured, oval-shaped, about 15 mm. long and half as broad. The elytra are closely and deeply punctured with small black punctures and marked in addition with a number of large blackish impressions which vary in different specimens.

The hind pair of legs as in the other *Dytiscidæ* are long, and have the joints broadly flattened dorso-ventrally and form powerful organs of locomotion. The two anterior pairs of legs are of the normal size. The first three tarsal joints of the anterior pair of legs are in the male flattened out and together form a more or less circular disc, the under-surface of which forms a sucker by means of which the male is able to retain its hold on the female. The beetle, like the larva, is predaceous, but unlike the larva it devours the prey entire by grasping it by the two anterior pairs of legs and tearing it to pieces. As a rule, *Dytiscidæ* live on live prey, but it is probable that when food is scarce, they are not averse to even dead insects.

Sandracottus dejeani, Aube, has been observed to feed on dead caterpillars of *Euxoa segetis* and *E. spinifera*, numbers of which had fallen into the drains around the college buildings and had got drowned ; every now and again a beetle could be observed rising to the surface with a caterpillar grasped by the anterior pairs of legs. The skin is ripped along the mid-ventral line and after the soft tissues have been eaten, the hard integument is thrown away.

The beetle, like the larva, cannot remain under water without coming occasionally to the surface to breathe. It is lighter than water and can only remain below by holding on to some object by the two anterior pairs of legs. When obliged to come to the surface, it merely lets go its hold and rises without any effort usually

with the hind end uppermost and hangs from the surface in an oblique attitude with the head downwards and the tip of the body at the surface. The tip of the abdomen is then curved inwards, leaving a narrow space between it and the elytra, and air passes into the space lying between the elytra and the dorsal surface of the abdomen from whence it is taken into the body through the abdominal spiracles. The period during which the beetle remains on the surface taking in air, varies considerably; when alarmed and fearing danger, it barely remains for a couple of seconds on the surface before it dives again below; on other occasions it may remain hanging from the surface for minutes together.

Hyphydrus renardi, Sev.

Hyphydrus renardi, Sev., is one of the smaller *Dytiscidæ*, belonging to the sub-family *Hyphydrini;* it is a small, oval-shaped thick-set beetle, about 3 mm. long and 2½ mm. broad, brown-coloured with black markings on the thorax and elytra (Plate XXII, Fig. 2).

Larva:—Larvæ were observed at Pusa during the hot weather in the drains around the college buildings and the jute pits. The larva (Plate XXII, Fig. 1) is small, elongate, broad in the middle and narrowed towards either end, but much more towards the posterior than the anterior end; it is convex above and more or less flattened beneath. It is about 5½ mm. long and 1½ mm. broad. The head is small, with the sides rounded and narrowed anteriorly; the clypeus is produced forwards into a curious beak-like process, which is about ½ mm. long, flattened from above downwards and rounded at the apex. The mandibles are long, slender, curved and sharply-pointed; they curve around the beak on either side with the tips touching it just below the apex. The antennæ are short, three-jointed. A pair of eyes is present, each composed of a number of closely placed ocelli. The prothorax is large, with the sides strongly rounded and slightly narrowed anteriorly; the meso- and meta-thorax together are as long as the prothorax, the body tapers posteriorly, the last segment but one is

EXPLANATION OF PLATE XXII.

Hyphydrus renardi.

(1). Full-grown larva, dorsal view.
(2). Imago.

Hypophorus aper.

(3). Full-grown larva, dorsal view.
(4). Imago.

PLATE XXII.

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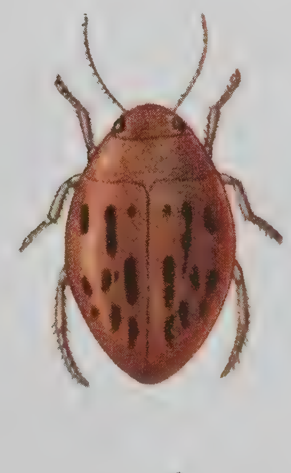

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narrow and short, the last much longer, slender and tapering to a point. From the apex of the last segment but one is given off a pair of long stiff spines which project a little beyond the tip of the body. The head is pale yellow with a large irregularly-shaped dark brown patch near each eye. The prothorax is yellow except for a long transverse dark brown patch at the base. The meso- and metathorax, and the first four abdominal segments are dark brown, segments 7-9 pale yellow, the remaining segments dark brown except the lower half of the last segment which is pale brown. The under-surface is yellowish. The thorax and the abdomen of the larva are pubescent above.

The larva remains clinging to the sides or the bottom of its habitat. It breathes by means of the terminal pair of spiracles at the tip of the body. When about to breathe, the larva runs up the sides of the drains and when close to the surface turns upside down and exposes the tip of the body to the air. The larvæ are predaceous, but were themselves in turn attacked and devoured by the larva of *Sternolophus unicolor*, Cast.

Pupa.—The larvæ, like those of the other Dytiscidæ, leave the water when full grown and burrow down into the mud, to pupate.

The pupa is broadly oval, pale yellow, $3\frac{1}{4}$ mm. long and 2 mm. broad. The head is large, broad, and marked with a number of spines on the vertex, and is bent down on the thorax. The prothorax is very large, with the disc convex and bearing a number of irregularly placed spines. The abdomen is gradually narrowed behind. The last segment is small and furnished apically with a pair of long spines; the rudiments of the elytra, wings, and legs of the imago lie, as usual, folded on the ventral surface and at the sides; the dorsal surface of the abdomen is marked with a number of irregularly scattered spines.

The pupal period is short, lasting from 6 to 8 days.

Hyphoporus aper, Shp.

The genus *Hyphoporus* belongs to the sub-family *Hydroporini* of the Dytiscidæ. *Hyphoporus aper*, Shp. (Plate XXII, Fig. 4) is

a small oval-shaped thick-set beetle, 5 mm. long and 3 mm. broad, reddish brown with the thorax and elytra closely and coarsely punctured. *Hyphoporus aper* is common in Pusa in the river during the cold weather. The beetle breeds apparently only in the cold weather, larvæ and pupæ being fairly common during December, January and February along the river banks. They are found at a depth of from 1—2 inches below the soil, each in a separate small round hole which is smooth in the inside.

Larva :—The larva (Plate XXII, Fig. 3) is elongate, spindle-shaped, broad in the middle and gradually narrowed at either end, pale brown-coloured, flattened from above downwards, about 6 mm. long and 1½ mm. broad. The head is large, with the sides rounded and narrowing anteriorly and produced forwards into a short triangular-shaped process, rounded at the apex, which is shorter and less pronounced than that of *Hyphydrus renardi ;* the mandibles are of the type described already, long, slender, curved and finely pointed. Eyes are present in the shape of a pair of black patches, each composed of a number of ocelli. The prothorax is large with the sides rounded, the meso- and meta- thorax are comparatively short, both together being as long as the prothorax. The body from about the middle gradually tapers behind, the last two segments are narrow, cylindrical shaped, and from the tip of the last segment is given off a pair of long slender processes half as long as the body. The integument is hardened on the dorsal surface, but remains soft beneath except for the last two segments which are completely enclosed in a hard sheath. The usual three pairs of legs are present, each ending in a pair of long claws and provided with fringes of long hairs.

Pupa :—The pupa is oval-shaped, whitish or pale yellow, 4 mm. long and about half as broad, the head is large, broad, smooth, and with the mouth parts is bent down on the thorax, the prothorax is about twice as broad as long, the anterior margin nearly straight, the posterior bisinuate, the sides rounded ; the meso- and meta-thorax are comparatively short. The abdomen is gradually narrowed behind, the last segment is produced laterally into a short

process and furnished at the apex with a pair of strong spines. The rudiments of the wings, legs and elytra of the future imago lie folded as usual along the ventral surface and at the sides, the pupa is provided on the dorsal surface with a number of irregularly scattered small stiff spines.

The pupal period is short, lasting for about a week ; larvæ which entered the mud to pupate on the 8th February, pupated on the 9th February and emerged on the 15th February.

Dineutes unidentatus, Aube.

The genus *Dineutes* is placed by M. Regimbart in the subfamily Enhydrini of the family Gyrinidæ in his monograph on the family in "Genera Insectorum."

Dineutes unidentatus (Plate XXVI, Fig. 7) is common in Pusa during the hot weather in the river and during the monsoons in ponds and pits filled in by the rains. It is usually found in company with another species, *D. spinosus*, which superficially resembles it, but which can be distinguished from the former by its having the apex of the elytra produced at either angle into a sharp spine ; in *D. unidentatus* the sutural spines are absent, only the outer angles being spined.

The Larva :—The larva (Plate XXVI, Fig. 5.) is elongate, flattened, pale yellow, about 13 mm. long and about 2 mm. wide. The head is small, hard, pale brown-coloured, slightly longer than broad, a pair of eyes is present, each composed of a number of ocelli. The mandibles are long, slender, curved and sharply pointed. Near the base of the mandibles is given off a pair of short four-jointed antennæ with the basal joint very short and the three following joints relatively long. The prothorax is covered dorsally with a hard semi-circular plate which protects the whole segment except a narrow margin on either side. The meso- and meta-thorax are, like the abdominal segments, unprotected, the segments of the body are well marked and distinct. From each abdominal segment is given off at the base on either side a long tapering process fringed with hairs, the 9th abdominal segment

bearing in addition another pair of similar processes: a small slender 10th abdominal segment is present which is not furnished with the processes, but is provided at the tip with a pair of short curved hooks. The usual three pairs of thoracic legs are present, each provided at the tip with a pair of short claws.

The larvæ lead a concealed life, never leaving the bottom of the pond, but hiding among stones and submerged weeds and are consequently difficult to discover. Though a number of Gyrinid moults were found in 1910 in the month of October floating on the surface, a close search, after scraping the bottom and the sides of the pond with a dredging net, revealed only one larva. The larvæ feed on small insects: the one kept in the aquarium was fed on Chironomid larvæ and small aquatic bugs. The method of feeding is the same as that of the Dytiscid larva; the prey is grasped between the mandibles, the sharp points inserted into the tissues and the juices sucked out. The larva swims along the bottom by rapid serpentine motions of the body.

Unlike the Dytiscid or the Hydrophilid larva, the larva of *D. unidentatus* never comes to the surface for breathing. Respiration is carried on by means of the abdominal processes which function as gills. The main pair of air tubes run longitudinally along the body one on either side and appear in the living larva when it is seen from the dorsal surface as a pair of greenish black streaks, these give off branches one to each process which in their turn give off short lateral branches on either side.

Pupa :—The larvæ when about to pupate crawl out of the water and construct cocoons which are attached to the under-surface of blades of long grass fringing the margin of the ponds (Plate XXVI, Fig. 4). The cocoons are well above the surface, the distance above the water level varying from a few inches in some cases to as much as three feet in others. The cocoons are mud-coloured, oval, strongly convex above, and flattened below, about 8 mm. long and half as broad. They are of two kinds: either (1) composed of small bits of dry twigs and other vegetable débris found floating on the surface of water, or (2) they are formed

entirely of mud which is cemented by some secretion from the larva and forms into a hard crust. The larvæ lie coiled within the cocoon in a semi-circle with the head and the posterior end bent inwards.

The pupa (Plate XXVI, Fig. 6) is yellowish, oval-shaped with the anterior end broad, about 6 mm. long and $2\frac{1}{2}$ mm. across. The head with the mouth parts is bent downwards on the thorax. The prothorax is transverse, about twice as broad as long and provided at the anterior margin with a number of small stiff hairs or setæ. The abdomen is gradually narrowed behind with the last segment broadly rounded at the apex. The rudiments of the legs, wings and elytra of the future imago lie folded on the ventral surface and at the sides. The spines which are so characteristic of the Dytiscid and Hydrophilid pupa are absent. The pupal period is very short and lasts for about 7 days.

Imago :—The beetle is oval-shaped, strongly convex shiny black above, flattened and opaque below. It is 7 mm. long and 5 mm. broad. From their habit of living on the surface of water the *Gyrinidæ* are, perhaps with the *Hydrometridæ* which have a similar habit, the most commonly observed of aquatic insects. They move on the surface in short rapid circles occasionally resting on floating weeds by clinging to them with their anterior legs. Swimming is effected by the two posterior pairs of legs which are short and have the femora, tibia and tarsus broadly flattened from above downwards. When disturbed, they either dart away quickly or dive below the surface, where they remain clinging by the anterior pair of legs to submerged weeds. They, however, soon let go their hold and rise to the surface to begin again their gyrations. The *Gyrinidæ* are gregarious, in habits, being usually found in numbers together. Respiration unlike that in the larva is aerial, and when the beetle dives below the surface it carries a bubble of air with it and this clings to the apex of the body which is pubescent.

Dineutes first appears during the early hot weather, breeds during the rains, and is found until cold weather sets in, hibernating in the imago state as probably all the Gyrinidæ do. In the first week of February 1910, numbers of *Orectochilus gangeticus*

and *O. aeneipennis* were observed swimming about on the surface of water. In a couple of days they disappeared and were not observed again until the beginning of March. A spell of warm weather had perhaps drawn them out of their winter burrows. The beetle flies in search of fresh habitats, and as soon as the ponds, which have been dry during the hot weather, are filled by the rains, they are found to be inhabited by them.

Orechtochilus, the other common genus of *Gyrinidæ* found in Pusa, confines itself to the river and has not been found in ponds, probably preferring flowing water.

Hydrophilus, Sp.

The Eggs :—Eggs are laid in whitish fibrous cocoons (Plate XXIII, Figs. 1 & 2), oval or rounded, from 15 to 20 mm. long and about 10 mm. broad. On one side the cocoon is flattened and depressed, the margin around the depression raised into a rim, from the middle of the rim on the dorsal surface there springs a long tapering process which is darker in colour than the rest of the cocoon and measures about 10 mm. from base to tip. The cocoons are always attached by their upper surface to any floating object, a piece of weed or a leaf, and float freely with the spike directed upwards. The upper surface with the entire spike lies out of water. The rest of the cocoon remains under.

The eggs are laid within the cocoon; they are glued to the bottom on end close together and enveloped in a loose tissue of fine silky fibres. The eggs occupy only a part of the cavity, the rest being filled with a network of the same fibres with which the eggs are covered. (Plate XXIII, Fig. 3.)

It is not clear what useful purpose is served by the spike. In the natural position the spike is always directed upwards, and this end is secured partly by laying the relatively heavy eggs on the bottom of the cocoon and partly by attaching the cocoon to some floating object which further serves to keep it in an upright position. The spike is supposed to serve the purpose of supplying air to the eggs within the cocoon, but in all the cocoons examined the

EXPLANATION OF PLATE XXIII.

Hydrophilus sp.

(1). Egg Cocoon, dorsal view.

(2). „ „ side view.

(3). Egg Cocoon with the upper surface removed showing the eggs in the natural position within the cocoon.

(4). Single egg.

(5). Full-grown larva, dorsal view.

(6) Pupa, ventral view.

(7). Imago.

PLATE XXIII.

apical end of the spike was not open but closed. The removal of the spike has no effect on the eggs; the spike of one of the cocoons was cut off up to the base and from another the entire upper surface with the spike removed and both floated in a dish of water. The eggs from both hatched in the same manner as from cocoons with the spike entire. Eggs which have become wet do not hatch, as was observed in the case of some which were removed from the cocoon and placed in water; these gradually sank to the bottom. A cocoon with the entire spike was submerged under water; in this case also the eggs did not hatch, as they had become wet by the water permeating through the egg case. A cocoon contains on an average from about 40 to 60 eggs.

The egg is soft, smooth, pale yellow, cylindrical with rounded ends and slightly curved; it is $3\frac{1}{2}$ mm. long and $\frac{3}{4}$ mm. broad. The egg-shell is thin and transparent. The eggs take four or five days to hatch. As the embryo develops, the colour of the egg turns from pale yellow to grayish. The gray colour starts at the upper end of the egg and gradually spreads downwards until the whole of the egg except the lower end turns grayish. The larva lies within the egg with its head at the lower end and its tail at the upper end of the egg. The eyes of the larva can be distinguished as a pair of black spots at the lower end of the egg.

Larva.—The larvæ soon after hatching remain within the cocoon for about 12 hours when they escape into the water through apertures which they make towards the lower end of the flattened surface of the cocoon. The larva, when just hatched, is ash coloured, elongate, flattened from above downwards, about 11 to 12 mm. long; the head is large, flattened, with a pair of short antennæ; the palpi are long, the mandibles are stout and short with a broad inner edge; a pair of eyes is present each composed of a number of ocelli. The body gradually tapers behind, and is furnished at the apex with a pair of short thick processes. The usual three pairs of legs are present.

The larvæ feed on snails; the snail is grasped between the mandibles, the head sharply bent backwards and the snail pressed

against the thorax which is bent into a curve. The larva does not crush the shell in order to get at the flesh but removes it by neatly cutting a narrow slit along the circumference of the shell, by chipping it off bit by bit. Unlike the larva of a Dytiscid or a Gyrinid, the larva of *Hydrophilus* devours the whole of the prey and there is thus a corresponding change in the shape of the mandibles, the long curved slender and perforated mandibles of the former giving place to the short but stout and broadly edged ones of the latter.

As the larvæ grow, they moult. When about to moult, the larva stops feeding and lies at or near the surface. The thorax is bent into a hump causing the integument to stretch out until a slit is formed along the mid-dorsal line extending from the base of the head to the first or second abdominal segment. The head with the mouth parts is first slowly drawn out of the old skin, which is gradually slipped back towards the hind end of the body from which it is ultimately cast off; just after the moult the head, mouth parts and legs of the newly moulted larva are milky white, the upper part and the sides of the body pale coloured. In about a couple of hours the body acquires the normal grayish colour.

The larva (Plate XXIII, Fig. 5), when fully developed, measures $2\frac{1}{2}$ inches in length and 9 mm. in breadth. It is elongate, flattened dorso-ventrally, gray above, dirty white below. The head is large, semi-circular shaped and more or less flattened above, about 5 mm. long and as broad. Antennæ are four-jointed, the basal joint stout and long, the three remaining joints short and slender, the basal joint slightly longer than the three remaining joints put together. The eyes are present in the shape of a pair of black irregular patches each composed of a number of ocelli; they are best seen just after a moult where they are conspicuous on the white background but they become less distinct when the larva acquires its normal gray colour. The mandibles are stout and bluntly pointed at the apex. The palpi are long and five-jointed, the basal joint stout and long equal in length to the remaining four joints which are also much more slender. The colour of the head is pale brown with indistinct darker longitudinal streaks.

The prothorax is large, rectangular shaped, with the integument chitinized and forming a hard plate above and below. The body is broadest at the middle from which point it gently tapers at either end but more towards the posterior than the anterior end; from the apex of the body are given off a pair of short, thick, fleshy processes. The anus opens ventrally just above the base of the processes.

Respiration is aerial and is carried on by means of the pair of terminal spiracles which are situated at the base of a shallow pouch-shaped cavity at the apex of the body. The cavity can be opened or closed at will. The spiracles open into the pair of main longitudinal air tubes which run along the body one on either side and give off branches. When the larva wants to breathe, the hind end is raised up until the tip of the body is on a level with the surface of water; the cavity is opened and air drawn in by slow alternate contractions and expansions of the hind segments of the body, when a sufficient supply of air has been taken in, the cavity is closed and the tail-end withdrawn below the surface; the same process is repeated from time to time at varying intervals, each time the larva wants to take in a fresh supply of air.

The larvæ make a sharp squeaking noise when annoyed and squirt a quantity of dirty coloured sticky fluid from the hind end of the abdomen; these devices are obviously protective as the larvæ have never been observed to take to this unless annoyed or attacked. Living as they do in shallow water and even when in deeper water lying close to the banks, they must be subject to constant attacks from enemies particularly wading birds. A small bird which had inadvertently seized a larva would probably be startled by the sudden squeak and the spurting of the fluid and drop the prey quickly.

When full-grown, the larva crawls out of the water, burrows into the earth where it makes a round hole about an inch and a half in diameter within which it pupates. The table below gives the duration of the life-history :—

Egg case found.	Eggs hatched.	1st Moult.	2nd Moult	Full-grown.	Pupated.	Emerged.
9-VIII.	On the night of the 13th.	17-VIII.	21-VIII.	24-VIII.	25-VIII.	9-IX.
			22-VIII.	27-VIII.	29-VIII.	{10-IX. 11-IX.

It rests in the larval stage for about a couple of days before pupating. It lies in the cell on the ventral surface with the body bent into a gentle curve.

Pupa.—The pupa (Plate XXIII, Fig. 6) is broader and shorter than the larva, whitish, oval-shaped, about 33 mm. long and 13 mm. wide. The head is as long as broad and with the mouth parts is bent on the thorax. The prothorax is large, much broader than long with the sides rounded, the disc convex and provided at either anterior angle with three long strongly curved spines. The meso- and meta-thorax are narrower than the prothorax, the former with a triangular shaped raised space in the middle and a broad depression on either side of it ; both the meso- and meta-thorax bear each on the disc a pair of widely separated spines. The abdomen gradually narrows behind, the last segment is short and bears at the apex a pair of long stiff processes spirally ridged and each tipped at the apex with a pair of minute spines. Each abdominal segment (except the last two) is provided on either side with a pair of long spines. The rudiments of the legs, elytra and wings of the future imago lie folded on the ventral surface and at the sides. The pupa lies in its cell in a characteristic attitude, it lies on its ventral surface with the dorsal surface turned upwards and arched but the body does not come into contact with the walls of the cell but rests on the thoracic and apical spines as on a tripod as shown in the accompanying diagram (Fig. 2).

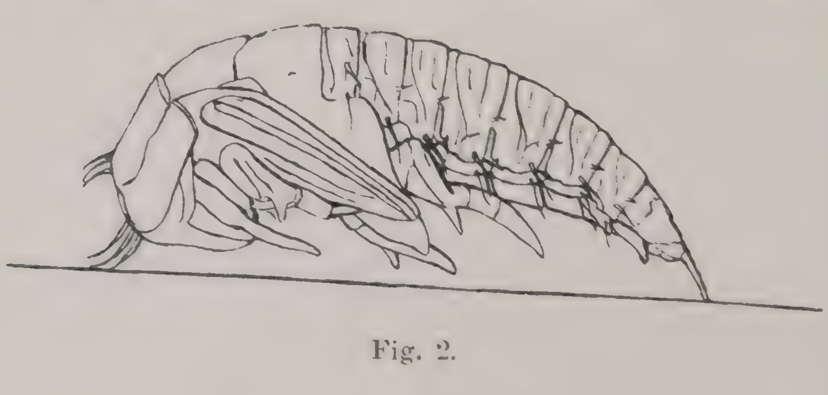


Fig. 2.

After transforming into an imago, the beetle remains in the cell for 2 to 3 days before it emerges out of it.

The table given below shows the changes, with the dates, undergone by the larva after entering the soil to pupate :—

Entered the earth.	Pupated.	Transformed to imago.	Emerged out of the cell.
29-VIII.	1-IX.	6-IX.	9-IX.
29-VIII.	2-IX.	8-IX.	10-IX.

The beetle is 27 mm. long and 13 mm. broad, oval shaped, strongly convex and shiny black above, and opaque below. (Plate XXIII, Fig. 7.) The metasternum is produced backwards into a long sharply pointed spine which reaches to the middle of third abdominal segment. The beetle swims quickly but its movements are less graceful than that of a Dytiscid. This is due to the fact that in the former the hind pair of legs strike the water simultaneously, in the latter the two posterior pairs of legs which are the organs of locomotion and which have the joints flattened, move alternately as in walking, consequently it gives the beetle an awkward gait.

The under-surface of Hydrophilus when seen from below through the water appears glistening white and is due to the film of air which clings to the sides of the thorax and the abdomen. When Hydrophilus wants to breathe, it rises to the surface head foremost. The head is pushed out of the water and by turning it on one side a cleft is formed between the head and the angle of the prothorax and the club of the antenna is brought to lie in the cleft. The abdominal segments during the act of respiration keep moving up and down. When a sufficient supply of air has been taken the head is withdrawn under water.

Hydrophilus first appears during the hot weather and breeds apparently only during the rains, as no cocoons have been observed during the hot weather. It probably hibernates as imago.

Helochares Sp. (Plate XXIV, Fig. 5.)

Helochares is common in Pusa during the cold weather and the early part of the hot weather in the river where it usually lives

in shallow water close to the banks hiding amongst the algæ and other weeds which grow there.

The female carries the eggs with it in a cocoon attached to its abdomen (Plate XXIV, Fig. 1). The cocoon is in the shape of a small bag, dirty white coloured, with thin paper-like walls; it measures 3 mm. by 2 mm. and is attached to the abdomen just below the hind coxæ and projects considerably beyond the apex of the body. *Helochares* affords an example of maternal instinct, which is rare as a rule among insects, and it is displayed at the cost of considerable inconvenience to the beetle; for it is a poor swimmer and burdened as it is with the egg case, it is considerably hampered in its movements being only able to slowly drag itself along submerged weeds.

The eggs lie closely packed in the case, each case containing on an average about 60 eggs.

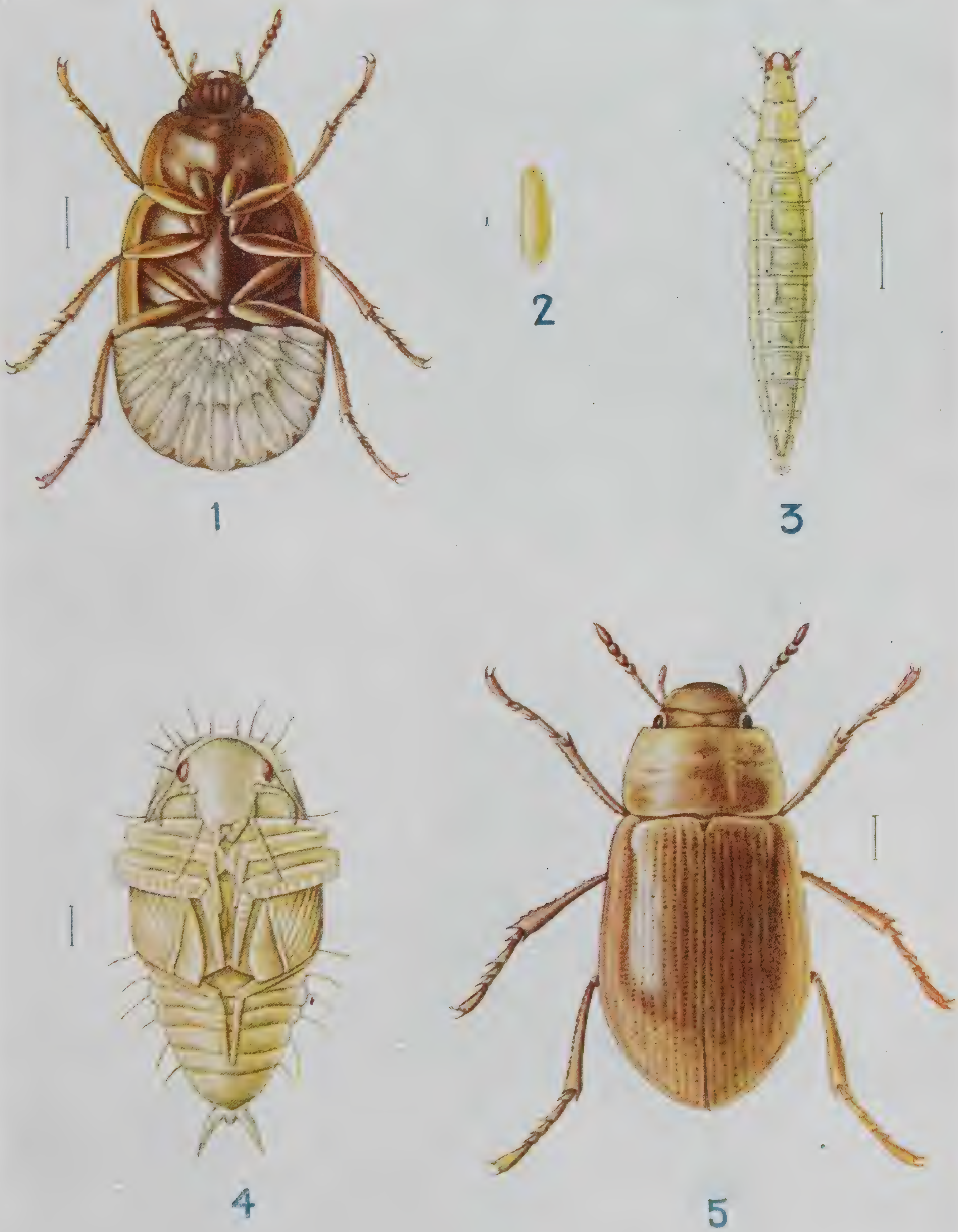
Larva.—The larva just after hatching is about 2 mm. long and $\frac{1}{2}$ mm. broad. When full-grown it is 10 mm. long and $1\frac{3}{4}$ mm. broad. (Plate XXIV, Fig. 3.) It is elongate, stout bodied, flattened from above downwards and of a pale ash colour. The head is large, slightly longer than broad; the mouth is furnished with a pair of long curved mandibles finely pointed at the tip and provided each on the inner side with a pair of sharp teeth; near the base of the mandibles is given off a pair of short antennæ; the palpi are long with the basal joint long and thick and the three following joints short and slender; eyes are present in the shape of a pair of black patches each composed of a number of ocelli. The prothorax is elongate with the sides narrowing anteriorly, much longer than broad. The meso- and meta-thorax are more transverse and shorter than the prothorax. The body is thickest about the middle from which point it narrows gradually towards either end but more towards the posterior than the anterior end; the last segment is elongate, longer and narrower than the preceding ones with the apex rounded and furnished apically with a pair of short processes. The head, pro- and meso-thorax are hard, the remaining segments remain soft but the integument is deeply

EXPLANATION OF PLATE XXIV.

Helochares sp.

(1). Female, ventral view showing the egg-case attached to the abdomen.
(2). Single egg.
(3). Full-grown larva, dorsal view.
(4). Pupa, ventral view.
(5). Imago.

PLATE XXIV.



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wrinkled. The usual three pairs of thoracic legs are present, each ending in a single claw. Respiration is effected by the terminal pair of spiracles which are situated in a shallow cup-shaped cavity fringed with hairs. The larva breathes in the usual way by bringing the tip of its body on a level with the surface of the water. When full-grown the larva leaves the water, crawls on to the banks, makes a small round hole within the mud and pupates in it.

Pupa.—The pupa is broadly oval, pale yellow, 5 mm. long and a little less than 3 mm. broad (Plate XXIV, Fig. 4). Head is smooth, large, with the mouth parts bent down on the thorax, prothorax very large, the sides slightly narrowed anteriorly, the disc strongly convex and marked with a number of spines; a row of 8 spines on the anterior margin, a row of similar number on the posterior margin, a pair on the middle of the disc. The meso- and meta-thorax are comparatively shorter than the prothorax and provided each with a pair of widely separated spines on the middle of the disc. The abdomen is gradually narrowed posteriorly and provided with a row of long spines on either side and a number of shorter spines scattered on the dorsal surface. The apex of the abdomen is rounded and provided with a pair of stiff divergent processes each ending at the tip in a long spine. The rudiments of the legs, wings and elytra lie folded on the ventral surface and at the sides.

The table below gives the duration of the life-history :—

Egg case found.	Egg hatched.	Larva full-grown.	Pupated.	Emerged.
6-IV.	9-IV.	26-IV.	26-IV.	2-V.

The life-history from egg to imago thus takes about 23 days to complete. The beetle is oval-shaped, olive brown coloured, 5 mm. long and about 3 mm. broad.

Sternolophus unicolor, Cast.

(Plate XXV, Fig. 3.)

S. unicolor, Cast., is an oval-shaped blackish beetle, with the sides of the elytra paler coloured, measuring about 9 mm. in length

and about 5 mm. in breadth. The metasternum is produced posteriorly into a spine, which is much shorter and more slender than that of *Hydrophilus*, reaching only to the first abdominal segment. It is abundant in shallow water.

Larva.—The larvæ have been found in the drains around the Pusa College and in the jute pits during the hot weather and the rains. The larva (Plate XXV, Fig. 1) is dirty white coloured, elongate and thick-bodied ; it is flattened dorso-ventrally and when full-grown is about 15 mm. long and 3½ mm. broad. Head is large, pale brown, scarcely longer than broad, flattened above. A pair of eyes is present each formed of a number of ocelli. The mandibles are long, curved, finely pointed and bear on the inner side of each at the middle a pair of sharp teeth. The antennæ are short and three-jointed, the palpi are long and four-jointed, the basal joint long, the three following joints short. The prothorax is longer than broad with the sides narrowed anteriorly, the meso- and metathorax are together as long as the prothorax. The segments behind the metathorax gradually widen up to about the middle from which point the body gently tapers posteriorly. The last segment is small and rounded at the apex ; from the middle of each abdominal segment is given off on either side a short backwardly directed process furnished with scattered hairs. The head and prothorax are hard, the rest of the body soft, but deeply and transversely wrinkled. The usual three pairs of jointed thoracic legs are present each ending in a single claw.

The larvæ usually remained clinging to the sides of the drains or crawling along the bottom. Respiration is carried on by means of the pair of terminal spiracles situated in a small rounded depression at the tip of the abdomen. Every now and again a larva could be observed running up the sides of the drains and when near the surface it would turn itself upside down and bring the tip of the body on a level with the surface of water. When the larva lies, as it often does, a little below the surface, it can gain access to the air without moving from its position. The lower segments

EXPLANATION OF PLATE XXV

Sternolophus unicolor.

(1). Full-grown larva, dorsal view.
(2). Pupa, ventral view.
(3). Imago.

PLATE XXV.

1

2

3

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of the abdomen are elastic and they can be elongated or retracted at will. All that the larva has to do when it requires air is to lengthen out the hind end of the abdomen until the tip is above the surface and then draw it beneath again by contracting the muscles.

Pupa.—The larva when about to pupate leaves the water and burrows down into the mud where it makes a round hole smooth in the inside within which it lies. The pupa (Plate XXV, Fig. 2) is shorter than the larva, broadly oval, whitish coloured, about 9 mm. long and 2½ mm. broad. The head is large, smooth and with the mouth parts is bent well down on the thorax. The prothorax is large with the disc strongly convex and marked with a row of spines on the anterior margin, a similar row on the posterior margin, a pair on either side near each angle and a pair on the middle of the disc. The meso- and meta-thorax are comparatively short, the abdomen gradually narrowed posteriorly and the apex is furnished with a pair of long spines. The pupal period lasts for about a week.

Scirtes grandis, Mots.

(Plate XXVI, Fig. 3.)

The larvæ of one species of *Dascillidæ* have been found in Pusa leading an aquatic life. The specimens agree with those taken in Belgaum by Mr. H. E. Andrewes and identified by Bourgeois as *Scirtes grandis*, Mots. They have been observed in the drains around the college buildings from the beginning of the hot weather to the beginning of the cold season.

Larva.—The larvæ (Plate XXVI, Fig. 1) are elongate, flattened dorso-ventrally, slightly convex above and measure when full-grown about 8 mm. in length and 2½ mm. in breadth. The head is more or less flattened, more than twice as broad as long and partly retracted within the prothorax. The mouth parts are well developed; the labrum is large, semi-circular with the anterior margin concave; the mandibles are short and stout, triangular, curved outwardly, sinuous along the inner margin

with the apex finely pointed; the eyes are small, inconspicuous; the maxillæ are well developed with a broad inner lobe and a short four-jointed palpus. The antennæ are characteristic, being quite unlike those found in Coleopterous larvæ, which are usually short and few-jointed. They are very long and slender, reaching to the apex of the fifth abdominal segment. They are setaceous, the first two joints comparatively long and followed by a great many minute joints, the antennæ gradually narrowing towards the apex. The pro meso- and meta-thorax are broad with the sides rounded; behind the metathorax the body becomes gradually narrowed. The last abdominal segment is small and truncate at the apex. Three pairs of legs are present each ending in a single long claw. The colour is dark brown to blackish above, dirty white below except the sides and the apical end which are fuscous; the legs are pale brown. The larvæ remain clinging to the sides of the drains, particularly at the corners where it is dark and shady. They run quickly up and down the sides of the drains or the bottom, but they are much lighter than water and cannot remain under the surface without clinging to some support and, when forced to let go their hold, they quickly rise to the surface. Occasionally they float passively on their backs on the surface. Respiration is aërial, the larva taking in air through the tip of its body; it runs up the sides of the drains and when close to the surface turns upside down exposing the tip of the body to the air; when going below the surface it carries a bubble of air attached to its hind end. When under water the larva protrudes from the hind end of the body a number of processes; they are slender finger-shaped, thin walled sacs, pale white in colour; their function is not clear, probably they are connected with the process of respiration. The larvæ are carnivorous feeding on small insects and not averse to them even when dead. When about to pupate the larva leaves the water and buries itself in the mud where it makes a small round hole within which it pupates.

Pupa.—The pupa (Plate XXVI, Fig. 2) is oval-shaped, pale yellow, 5 mm. long and 2 mm. broad. The head is round,

EXPLANATION OF PLATE XXVI.

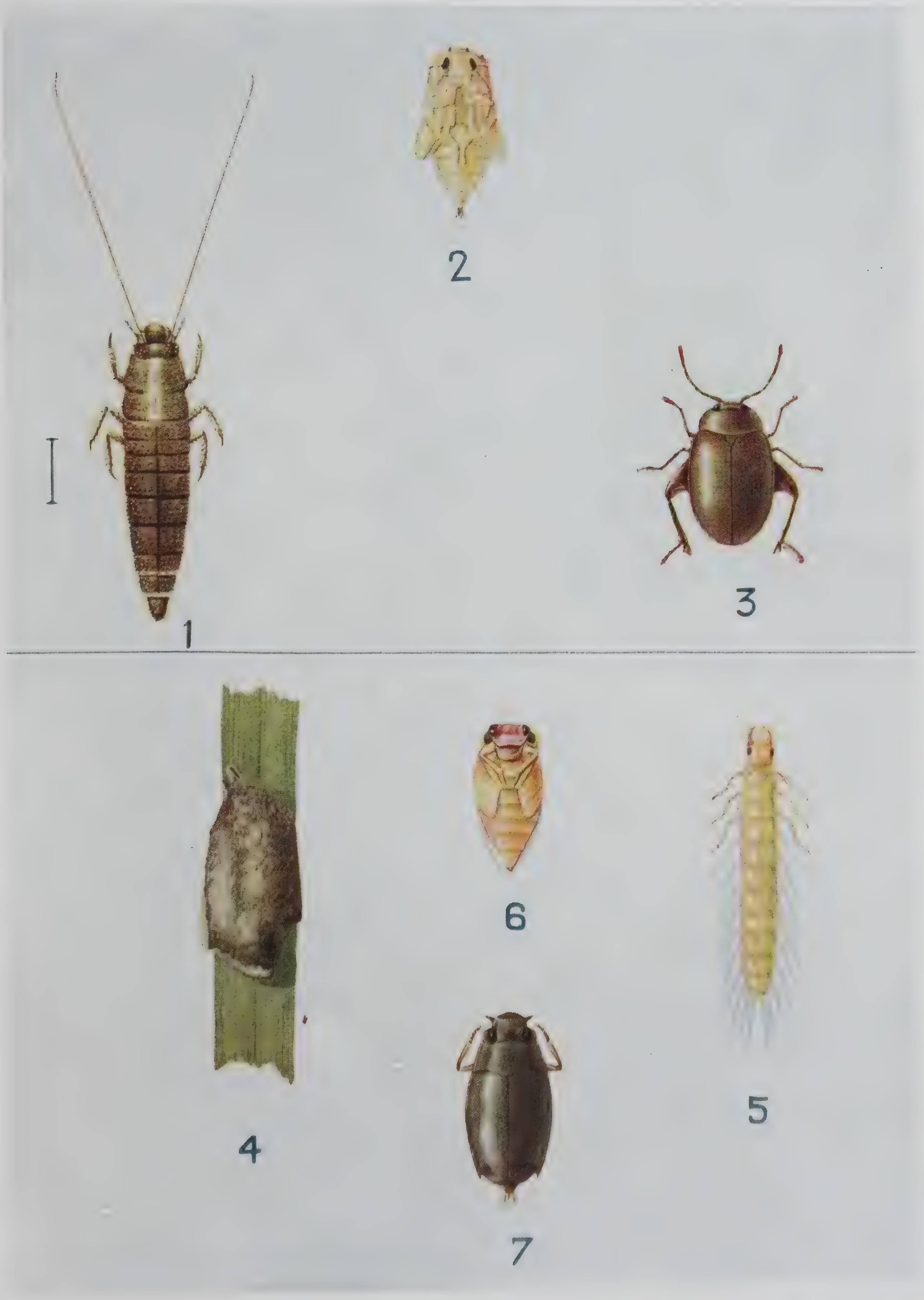
Scirtes grandis.

(1). Full-grown larva, dorsal view.
(2). Pupa, ventral view.
(3). Imago.

Dineutes unidentatus.

(4). Part of a blade of grass with the pupal case attached.
(5). Full-grown larva, dorsal view.
(6). Pupa.
(7). Imago.

PLATE XXVI.



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smooth. The vertex convex and with the mouth parts is bent down on the thorax. The prothorax is large with the posterior margin straight, the sides narrowing anteriorly, the disc convex. The anterior margin bears a pair of long sharply pointed spines, one near each angle. The meso-thorax is narrow and bears on the disc a pair of widely separated spines. The last but one abdominal segment is abruptly narrowed and truncate at the apex, the last very small, triangular and provided at the apex with a pair of long curved spines. The legs, wings and elytra lie as usual folded on the ventral surface and at the sides. The last pair of legs have the femora considerably dilated and the body is covered with closely placed erect stiff hairs. The pupal period lasts for 8 to 10 days. Larvæ which entered the mud to pupate on 17-VIII, emerged as beetles on 24-VIII and 26-VIII.

The beetle is reddish brown coloured, covered above with close short fulvous pubescence, oval-shaped, 5 mm. long and about 3 mm. broad ; the posterior femora are very much dilated like that of a flea beetle and the tibia is provided at the apex with a long sharply pointed spine.

PLATE XXVII

THE RHINOCEROS BEETLE OR THE BLACK BEETLE OF PALMS.
(Orýctes Rhinoceros, Linn.)

EXPLANATION OF PLATE XXVII.

ORYCTES RHINOCEROS.

Fig. 1. Eggs, that on left newly laid, that on right about to hatch.
„ 2. Young larva, natural size.
„ 3. Full-grown larva.
„ 4. Pupa.
„ 5. Beetle.
„ 6. Beetle, side-view of head of male, enlarged.
„ 7. „ „ „ female, „

The natural sizes of the stages shown in figures 3—5 are indicated by the hair-lines alongside each figure.

LIFE-HISTORIES OF INDIAN INSECTS—III.

THE RHINOCEROS BEETLE *(ORYCTES RHINOCEROS)* AND THE RED OR PALM WEEVIL *(RHYNCHOPHORUS FERRUGINEUS)*.

BY

C. C. GHOSH, B.A.,
Assistant to the Imperial Entomologist.

THE RHINOCEROS BEETLE, OR *THE BLACK PALM BEETLE.* (*ORYCTES RHINOCEROS*, LINN.)

(Plate XXVII).

Description.

The Rhinoceros Beetle or the Black Palm Beetle belongs to the sub-family Dynastinæ, family Scarabæidæ, of the Lamellicorn division of beetles. The description of the beetle in the Fauna of India Volume is quoted here for reference. (Vol. Coleoptera, Lamellicornia, Part I, pp. 278-279) :—

" Black or pitchy, with the lower surface reddish and clothed with a short tawny pubescence. It is elongate-cylindrical in shape. The *Clypeus* is sharply forked, with the points directed forwards, and the horn rather broad at the base, tapering to a blunt point and rugosely punctured, except at the base behind. The *pronotum* is almost as long as it is broad, strongly margined all round, with the front angles sharp, the hind angles obliterated, the sides strongly rounded behind and convergent in front. There is an approximately oval excavation extending from the front to beyond the middle of the disc and surrounded by a smooth carina, which forms behind a short truncate process directed forwards. There is an

elongate depression outside the carina on each side and another in each front angle. All the depressions are rugose and the remainder of the surface is smooth and shining but minutely punctured. The *scutellum* is rugose, with a smooth outer margin, and the *elytra* are strongly and closely punctured, the punctures being annular and forming a juxta-sutural line and three pairs of other lines rather wide apart, with closely punctured intervals; the sides and apices are more finely punctured. The *propygidium* is very large, lobate behind and rather closely ridged or striated. The front *tibia* is armed with four teeth, the uppermost one small, and there is also a sharp and conspicuous tooth on the lower face. The middle tibiæ are much shorter than the hind ones, and all are very acutely digitated at the end.

"The head and thorax are very similar in the two sexes, but the ♂ has generally a longer horn. The pygidium is protuberant in both sexes, but in the ♂ it is rounded, finely rugose and bare, except for a hairy strip at the anterior margin, while in the ♀ it is pointed and densely clothed with tawny hairs.

"Length 39-47 mm., breadth 18-22 mm.

"Ceylon; Madras: Malabar; Bombay: Kanara, Bandra; Bengal: Howrah; Tenasserim: Maliwon; Siam; Annam; Singapore; Pahang; Sumatra; Java; Celebes; Ceram; Amboyna; Philippine Islands; Formosa; Korea; Hongkong."

Occurrence and Damage Caused.

This beetle is referred to in Balfour's Agricultural Pests of India, pp. 43 and 89, as destructive to coconut trees in Malacca. References will be found in Indian Museum Notes, Vol. II, No. 6, page 149; and Vol. IV, No. 1, pp. 36-39, as destructive to palm trees, specially coconut palms in Singapur and Madras.

Mr. E. Hearn, Acting Deputy Superintendent, Konkan Survey, reported the occurrence of the beetle on 21st June 1893. Mr. E. H. Aitken, Assistant Collector of Salt Revenue, Kanara Range, and Mr. G. M. Woodrow, Lecturer in Botany and Agriculture, College of Science, Poona, reported its occurrence in August 1894. More

recently the Assistant Collector of Kanara made the following report on 26th March 1904 :—

"A black 'tumbi' attacks the toddy palms specially in the rains. It is a black-winged insect about $2\frac{1}{2}$ inches long and one half as thick. It bores into the stems on which the coconuts grow and lives in the hole thus made. The hole is made in the stem near the junction of the stem and the tree trunk.

"No toddy can be drawn from the stems thus attacked and in time the stem (Kone) dies. If a young tree is attacked the tree dies altogether. The tappers say that only one 'tumbi' lives in each stem ; and it attacks by preference those stems that are not tapped. They do not believe that it is attracted by the smell of a cut in the toddy palm.

"As to its life-history the tappers assert that it does not lay eggs in the holes it makes. The Abkari Sub-Inspector says that the beetle is developed from a large white grub which lives in dung pits.

"I have secured half a dozen specimens * * * *."

Mr. H. Ormerod reported the occurrence of the beetles in coconut plantations about 2 years old, in Bangalore district on the 15th May 1909, and said, "These attacks are said to continue all the year round, but to be at their height in the wet season. They recur every year."

Mr. A. M. D'Cruz, Horticulturist, Bombay, said in his letter, dated 11th January 1910, that he collected specimens of *Oryctes* and *Rhynchophorus* beetles with their larvæ from young coconut trees in a plantation of Uran, where considerable damage was being done.

Dr. H. H. Mann, the Principal of the Agricultural College, Poona, reported attacks of the beetles in toddy gardens near Poona on the 10th June 1910.

On the 26th November 1909, 60 apparently full-grown larvæ of *Oryctes rhinoceros* were collected from the old thatched roof of a hut in a village near Pusa. The thatching was *dabh* grass (*Imperata arundinacea*, Cyrill), which was in a rotting condition. The roof was beaten and the grubs dropped on the ground. The grubs were kept in a big trough filled with farm-yard manure and having a layer of earth at the bottom. On the 14th January 1910, another

lot of 20 apparently full-grown larvæ was collected from a heap of cowdung manure and kept with the previous lot. They passed the winter in the larval condition. Three came out as beetles on the 9th May 1910 ; 39 more came out by the 27th May. On the 28th May two were found as pupæ and 3 were yet in the larval state ; these could not stand the disturbance and died. On the 17th February 1911, a boy from a neighbouring village brought 17 full-grown larvæ and he reported that he found them in a dead palm tree. On later enquiry it was ascertained that two of the grubs were found in a small dead palm tree which had been cut down and was in a rotting condition, and the rest were found in a dung heap. These also were similarly kept but in earth only. On the 5th May one beetle had emerged in the Insectary, and beetles were being caught about this time by villagers who came to sell them. The trough was therefore examined on the 13th May. One was found to have cast off the pupal exuvium just then, as its wings were not yet fully stretched ; 8 beetles were found still in the pupal chambers ready to come out, with their limbs properly hardened and the colour fully developed. Two beetles had left the pupal chambers and bored their passage to a certain extent in order to be able to leave the earth. The rest of the larvæ were found dead. On the 10th May 1911, a village was visited and many palm trees examined with stems 8 or 9 feet high or less. Tops of trees with higher stems could not be got at. One tree was found freshly attacked. At the base of the emerging heart-leaf a hole about 1½ in. in diameter had been gnawed and chewed up fibrous matter thrown out in a mass. The chewed up mass was pulled out and the hole found to have gone down to a greater depth than could be reached. The hole was the work of a Rhinoceros beetle. The owner of the tree gave an exact description of the beetle. Into this hole the Palm Weevils would easily penetrate and lay eggs. The man said that he would place fried sand mixed with *gur* (treacle) into the hole and the insect would eat this stuff and die. Frequently, he said, he saved many trees in this way, but the remedy should be applied at as early a stage of the attack as possible. He as well as other villagers asserted that the trees do not always

die when attacked by these beetles ; most probably in many cases the growing part is not cut by the beetles which may bore down away from it. The villagers around Pusa know the *Rhynchophorus* larvæ, which they call *gararh* locally and always associate the death of the tree with *gararh*. The dates given above are important as showing the time of the year when the beetles emerge and attack the trees. In Bihar it has been seen consecutively for two years that the beetles appear in May. In the Insectary they did not live beyond June without any food. In the free natural condition, they most probably live till the rains when the greatest damage is reported. This also applies to other parts of India as will be seen from the dates of reports. The earliest report is dated 26th March from Kanara ; some beetles might have emerged at an early date. As regards the report of Mr. A. M. D'Cruz, dated 11th January, it seems he had been making a general investigation with specimens in his possession collected previously. It seems certain that beetles emerge after winter and the majority of them about May. In winter the grubs are very prominent in manure heaps and attract attention on account of their large size.

Habits.

The grubs of the Rhinoceros beetle are most probably harmless, as they are usually found in manure heaps and decaying vegetable matter. According to Mr. L. C. Brown, the breeding places comprise dead palm trees of several kinds, saw-dust, paddy straw, coconut, coffee and paddy husks and refuse heaps of all descriptions. Mr. C. S. Banks says in the "Philippine Journal of Science" that grubs were discovered in large numbers in coconut trees in which the manure-like material inside the trunk gave every evidence of having been made by the grubs themselves. He believes that the beetles lay eggs in the trunks of trees which they bore. But generally the grubs are seen to develop in manure or rubbish heaps or in decaying vegetable matter and the perfect beetles fly to the tops of palm trees, and bore down into the stem by making a big hole just at the base of the growing heart-leaf. All growers of palms and

tappers know this fact well. In most cases the growing part is cut through, and the result is that further growth is stopped and the tree ultimately dies. Besides, rain water lodges in the hole and sets up decay. Only the beetles cause damage in this way ; and as their number is very large, considerable damage is done. In infected areas almost all trees show signs of the boring of this beetle. As the holes are very large, being about $1\frac{1}{2}$ inches in diameter and loosely filled with the chewed up fibres thrown out by the beetle, they make an ideal hiding place for the Palm Weevils which thus at once get access to the soft part to lay eggs therein. If the weevils come and lay eggs, there is hardly any hope of the tree being saved. The Rhinoceros beetle bores through the unopened newly growing leaves or stalks of leaves. Therefore when the leaves open they show a ragged or trimmed appearance ; and also holes with chewed up fibres sticking to them are found in the leaf stalks. They bore the trees for feeding, and it was believed that they fed on the soft tissues inside. Mr. C. S. Banks says that they feed on the juice extracted from the fibres which are taken into the mouth for this purpose and then thrown out.

The holes which the beetles make in the trees serve as hiding places and probably they come out at night and fly about and infest other trees. In the Bulletin No. 4 (1910), of the Department of Agriculture, Burma, it is said that the beetles go down into the stem to some distance and there make a sort of a nest in which sometimes as many as 10 beetles congregate and remain hidden during the daytime, and issue at dusk to commence their feeding operations.

Sometimes it is said that the grubs of the Rhinoceros beetle eat the roots of living plants and kill them. Most probably the grubs of the common Cockchafer beetle (*Anomala varians*) are in such cases mistaken for *Oryctes* grubs. A young *Oryctes* grub will ordinarily be confused with an *Anomala* grub.

Life-history.

The life cycle of the Rhinoceros beetle is completed in about a year.

Eggs were laid between 29th May and 3rd June 1910.
They hatched between 10th and 13th June 1910.
The beetles emerged on the 5th May 1911.

EGG AND EGG-LAYING.

The egg when laid is about $3\frac{1}{2}$ mm. in one direction and 2 mm. in the other and looks oval. It gradually becomes rounder and bigger in size until before hatching it is about 4 mm. by about 3 or $3\frac{1}{4}$ mm. When laid the colour is white; but gradually it becomes rather dull and develops a very slight brownish or yellowish tinge: the surface is smooth. Before hatching the brown mandibles of the young larva are clearly visible and also the segmentation of the body under a lens.

In the Insectary the beetles were kept in a mass of moist farm-yard manure and eggs were deposited in this mass, singly. No special chamber or receptacle was formed for them, but they were placed loosely in the mass. A regular search used to be made in the morning and evening for eggs, and they were always found in the morning, evidently being laid at night. The beetles also were active and attempted to escape from the cage, only at night. During the daytime they always tried to hide, and when placed in the mass of earth or manure, they at once burrowed into it and remained still only when completely hidden. Eggs therefore seem to be laid at night only.

Several pairs were placed separately but only two females laid eggs—

One emerged on 25th May 1910.
She laid 3 eggs on 28th May 1910.
,, 2 ,, on 29th May 1910.
,, 2 ,, on 30th May 1910.
,, 1 egg on 1st June, and died on 19th June 1910.

The other emerged on 27th May 1910.
She laid 4 eggs on 3rd June 1910, and died on 16th June 1910.

The beetles were kept in the mass of manure and no other food was supplied.

Out of the 12 eggs secured only 7 hatched. The egg-stage lasts for about 10 to 12 days—

Eggs laid on 29th May, hatched on 10th June.
" " on 1st June, hatched on 11th June.
" " on 3rd June, hatched on 13th June.

Larva.

The young larva is about 6 mm. long, with flat ventral surface and convex back. It tapers gradually from the prothorax towards the hinder end. The head is about 3 mm. across, being about as broad as the prothorax; and the hind end is about $1\frac{1}{2}$ mm. broad. The head is yellowish brown with mandibles deep brown. Only 3 pairs of legs, pale yellow in colour, are present under the 3 thoracic segments. The colour of body when hatched is pale yellow, but looks grey after food is taken. The spiracles are yellow. On the segments there are numerous longish yellow-brown hairs. The grub always remains ventrally doubled.

The eggshell is not hard, but membranous and somewhat elastic. Alternate closing and opening of the mandibles help to burst the shell a little; then alternate expansion and contraction of the body burst the shell, which is cast off piecemeal, being rubbed off the body in the movements of the larva through the stuff in which eggs are laid.

The 7 larvæ which hatched in the Insectary between 10th and 13th June 1910, were placed in a cylinder filled with rotten cowdung only and having a layer of earth at the bottom and kept there, the mass of the dung being watered occasionally in order to keep it moist. They fed and grew. On the 20th October only two were found living. They seemed to have become full-grown, measuring about 90 mm. in length and about 22 mm. in breadth. On the 12th March they were found to be still in the larval state, but had hardly grown any longer as the measurements were practically the same as found in October. They did not, however, seem to be in a dormant state, nor had they prepared the pupal chamber, and they showed the usual activity when taken out. One of them emerged as a beetle on the 5th May and the other larva was found dead on 13th May.

The fully-grown larva measures about 100 mm. (4 inches) in length when extended, and about (or a little less than) 25 mm. (one inch) across the abdominal region, which is sglihtly thicker than the anterior part. It is a big soft-bodied fleshy grub with the skin, except in the region of the 3 anal segments, wrinkled transversely. The body is covered with many short brownish hairs which are not so numerous in the 3 anal segments. The head is brown and on each side of the prothorax there is a brown patch. The spiracles look like prominent brown spots. The three thoracic segments are provided each with one pair of legs, which are yellow and have got bristle-like brownish hairs. The colour is pale yellow or yellowish-white in the anterior part; the posterior part is dark grey. The grub always remains ventrally doubled.

Pupa and Pupation.

The grubs pupate in specially prepared oval chambers, measuring about $2\frac{1}{4}$ to $2\frac{1}{2}$ inches in one direction and about $1\frac{1}{4}$ inches in the other. The interior of the chamber is smooth and lined with a layer of a blackened substance which seems to be excrementitious. The walls are somewhat stiff and formed of earth agglutinated to some extent. The grubs went down to the bottom of the cylinder, more than a foot deep into the earth and formed the pupal chamber in the layer of earth. Other grubs have been reared, and although placed in loose moist earth they prepared similar pupal chambers. Most probably when the grubs breed in manure heaps, they go down until they reach the earth and pupate there. The actual pupal period could not be noticed, as, when disturbed at the time of pupation, almost in all cases they died. Also when the pupa was taken out from the pupal chamber the beetle could not emerge successfully. But from observations it seems the pupal stage lasts for about 10 to 15 days only.

The pupa measures about 45 mm. from head to anal end and about 20 mm. across the body. It is well represented in the plate (plate XXVII, fig. 4). Its dorsal outline is slightly convex, and the legs and wing cases are quite distinct and folded on the

ventral surface. There is a protuberance on the head and it represents the horn of the adult beetle. The colour is uniform brown.

The grubs pupate at some depth. Therefore the beetles have to break through the cocoon and bore their way out. They do not leave the pupal chamber until their limbs are perfectly hardened. Both the last larval and pupal exuvia are found in the chamber.

The Beetle.

The beetles shun light and live in hiding during the daytime. In the Insectary when they were taken out they would make no attempt to escape by flying, but would always try to get under something and hide. When placed in earth or dung they at once burrowed down into it. They bore by dorso-ventral movements of the head, the legs being used only as stakes and hardly helping in the actual operation of boring. At night they would come out of their hiding-places and try to escape, and in many cases actually escaped from the cylinders or troughs in which they were kept, unless the cover was well secured or a heavy one which could not be pushed open. The beetles are attracted to light, and it was found on two occasions while walking on the road in Pusa, with a lighted lantern on dark nights, that they fell on the road with a thud near the lantern, evidently being attracted by the light.

The males when touched or taken up on the hand or held in the fingers produce a creaking sound by moving the end of the abdomen up and down. There is a file on the dorsal side of this end, and the sound is produced by rubbing the edges of the elytra over this file.

There is a horn on the head of both sexes of the perfect beetle; hence the common name Rhinoceros beetle. The horn of the male is usually bigger than that of the female, but this is not the distinguishing point. The pygidium has to be examined in order to distinguish a male and a female; it is more rounded and bare in the male.

Preventive and Remedial Measures.

If the trees are visited regularly the attack of the Palm beetle is noticed easily, the rejected fibres attracting attention of even a

casual visitor. The hole should at once be probed with a stiff barbed wire, so as to pierce the beetle which will usually be found in the hole ; then a half turn is to be given to the wire and the beetle extracted. The hole is then to be stopped by plugging it with dry grass dipped in tar or with any stuff which will prevent access of either the Palm beetle or the Red Weevil, and of rainwater at the same time. Various things have been suggested for this purpose—for example, tar and sand, or clay and tar, or plaster, or cement.

There are various methods of treatment of infested trees in use among the growers, but the above method is to be preferred to all of them. In the Philippine Islands, they place sand and a coarse salt in the crown of the trees. They say sand gets in between the articulation of the head and thorax of the beetle where the constant friction sets up an irritation which eventually punctures the soft tissues and the insect dies. In Bihar, the cultivators first of all fry sand over a fire and mix it with treacle which is poured into the hole. They believe the insect eats this mixture and dies. In Mysore they hang little bags of salt over affected parts and pour water over the salt, so that the brine soaks into the hole and drives out the beetle. The beetle is said never to return to that tree. In some places they pour in urine or slaked lime or kerosene. But kerosene should be used with caution as it may kill the tree. Sometimes treacle is applied in a thin line from the ground up the stem into the hole with the belief that ants will be attracted and kill the beetle.

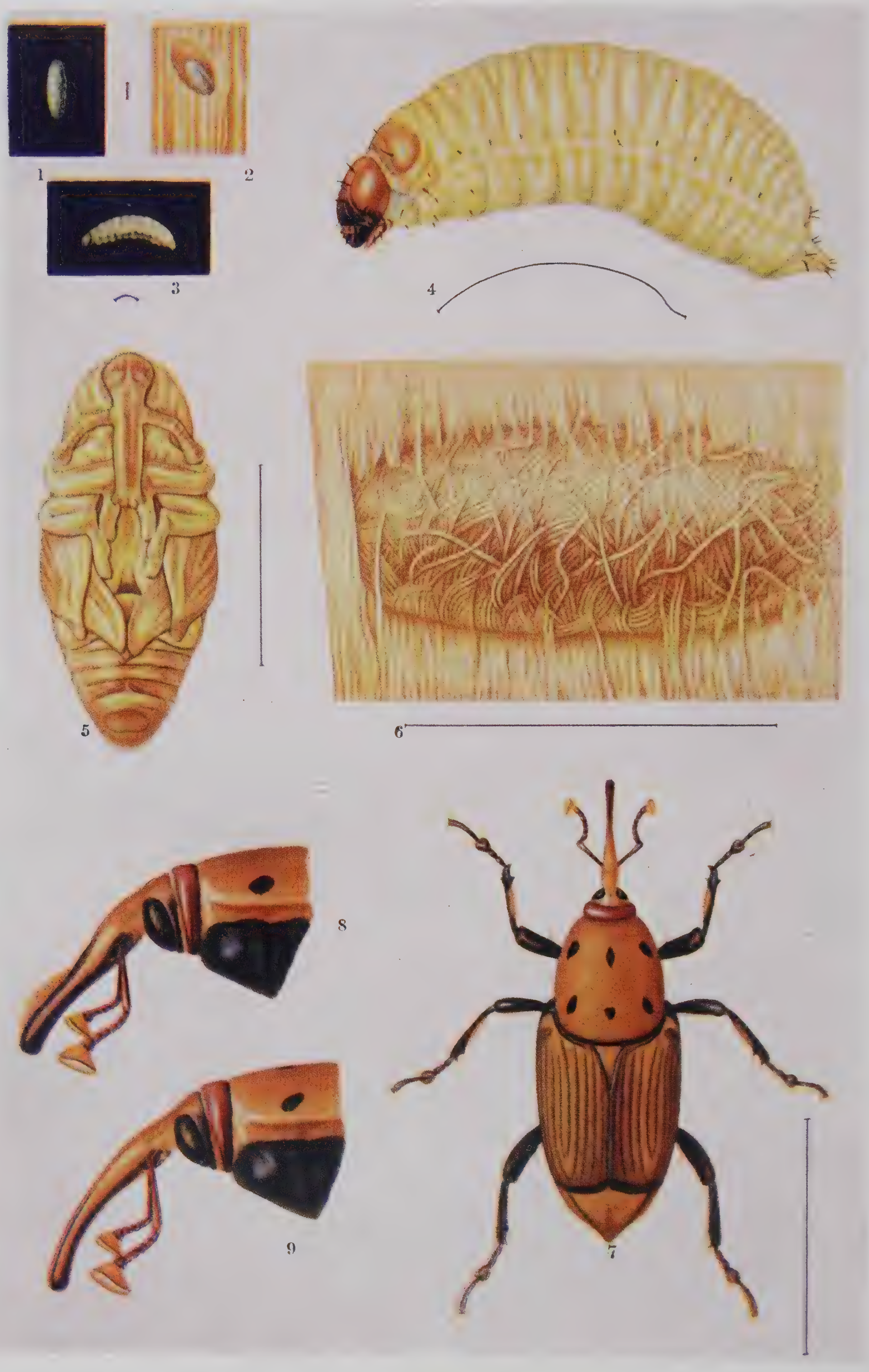
As a preventive measure the breeding places of the grubs,—*viz.*, manure or rubbish heaps, rotting vegetable masses, and rotten stumps or trunks of trees—should be attended to. They should be searched by being turned over about the month of November and the grubs picked out and destroyed by dropping them in hot water or crushing them under foot. The grubs will be about full-grown at this time and will thus be easily noticed. If practicable all such breeding places should be cleared off or burnt, the manure being scattered over fields as a fertilizer and not kept in a heap.

The beetles are attracted to light. Therefore light traps at night formed by placing a brightly burning lamp over a big trough

of water with a layer of kerosene oil on it, may cause the destruction of many beetles. The light traps should be placed at intervals in the plantation.

One method in use among the people is to place wide-mouthed vessels near the trees, fill them with water and allow mustard or rape cake to ferment in them. The smell is said to attract the beetles which drop into the water and get drowned.

PLATE XXVIII.



THE INDIAN PALM WEEVIL OR RED WEEVIL.

EXPLANATION OF PLATE XXVIII.

RHYNCHOPHORUS FERRUGINEUS.

Fig. 1. Egg.
" 2. Egg laid in hole in palm tissue.
" 3. Newly-hatched larva.
" 4. Full-grown larva.
" 5. Pupa.
" 6. Cocoon.
" 7. Adult weevil.
" 8. Side-view of head of male weevil, enlarged.
" 9. " " female "

The natural sizes of the stages shown in figures 1—7 are indicated by the hair-lines alongside each figure.

THE RED WEEVIL OR THE RED PALM BEETLE.
(*RHYNCHOPHORUS FERRUGINEUS*, OLIV.)

(Plate XXVIII.)

The known Palm Weevils.

The Palm Weevil (*Rhynchophorus ferrugineus*, Oliv.), usually known as the Red Beetle of Palms and the Rhinoceros Beetle (*Oryctes rhinoceros*) are the two specific pests of almost all kinds of palm in India. Of the two the weevil is capable of doing more injury, but fortunately it is not so numerous as the Rhinoceros beetle. It is found in India and the Malayan region and is known as the Indian or Asiatic Palm Weevil.

The Palm Weevil found in America and the West Indies is a distinct species, known to science as *Rhynchophorus palmarum*, Herbst, and generally called the American Palm Weevil. It is deep velvety black in colour with little or no lustre. Its range is said to extend from South California over Central and South America as far as Brazil, and it is also found in the West Indian Islands. Like the Indian Palm Weevil, it is said to feed on almost any kind of palm ; but unlike the Indian species it goes further and attacks sugar-cane in Barbadoes, British Guiana and Trinidad.

There is another closely allied species (*Rhynchophorus cruentatus*, Fabr.—*zimmermanni*, Fb.) which is known as the Palmetto Weevil, feeding on Sabal Palmetto. It is said to attack all kinds of small palms. It is a native of Florida and the Southern States of North America. It is usually dark black, but frequently specimens are found which are bright red or red with black spots. The grubs of both the American Palm Weevil and the Palmetto Weevil, commonly known as Gru-gru worms, are said to be eaten as a delicacy.

The Indian Palm Weevil is well represented in the plate (plate XXVIII, fig. 7). It is a big red-brown flattened insect with or without a few black spots on the thoracic region and with a long slightly curved snout. The snout of the male is provided with a brush of hairs above and is stouter (plate XXVIII, fig. 8). That of the female is more slender and devoid of any tuft of hairs (plate XXVIII, fig. 9). The elbowed antennæ are inserted near the base of the snout. The terminal joint of the antenna is thick, truncated, and somewhat spongy. The elytra are ribbed longitudinally and they do not entirely cover the end of the body.

The distribution is noted in the following places :—

Saharanpur ; Lucknow ; Buxar ; Bankipur ; Gaya ; Pusa ; Darjiling ; Dikang Valley ; Suleiman Range ; Shillong ; Sylhet ; Assam ; Moulmein ; Calcutta ; Singbhum ; Madras ; Bangalore ; Wynaad ; Andaman Islands and Ceylon.

Occurrence and Breeding Season.

The Indian Palm Weevil breeds throughout the year. It has been reported in April from Lucknow ; in October from Saharanpur (I. M. Notes, Vol. II, p. 8) ; in August from Noakhali ; in November from Trivandrum (I. M. Notes, Vol. V, p. 52), and Saugor, C. P. ; in May and December from Madras. Grubs were found at the time the reports were made. At Pusa grubs have been collected and reared in June, August and December ; and the weevils have been bred from December to June in the Pusa Insectary. There is no regularity in the occurrence of the broods ; therefore perfect weevils, pupæ, and larvæ in different stages of growth may be found together at the same time. Grubs and pupæ were sent in from Madras in December and weevils emerged from them in mid-winter on 20th and 25th December, and also between 25th December and 7th January. They, however, did not lay eggs in the Insectary till the beginning of March. On the other hand, pupæ and grubs, grown-up, as well as young, were collected early in the same month of March from an affected palm tree (*Palmyra*) in the neighbourhood of Pusa. Evidently breeding had continued in winter. Therefore it seems the Palm Weevil is never dormant throughout the whole year.

Life-Cycle.

The life-cycle of the Indian Palm Weevil was observed in the Insectary to occupy a period of from 48 to more than 82 days, the general average period being about 2 months. Several complete cycles are shown in the table below,—

Eggs laid.	Eggs hatched.	Larvæ formed Cocoon.	Weevil emerged.	Number of days from egg to emergence of imago.
	13. III.	13. V.	3. VI.	82 (from date of hatching of egg).
	15. III.	16. IV.	9. V.	55 (Do.)
15-16. III.	19. III.	1 on 18. IV.	10. V.	56
			1 on 19. V.	65
17-18. III.	21. III.	17. IV.	20. V.	64
17-18. III.	21. III.	19. IV.	10. V.	54
18-19. III.	21-22. III.	12. V.	30. V.	74
19-20. III.	22-23. III.	1 on 19. IV.	14. V.	57
		1 on 25. IV.	17. V.	60
22-23. III.	26. III.	2 on 19. IV.	1 on 9. V.	48
			1 on 12. V.	51
		1 on 25. IV.	15. V.	54
25. III.	29. III.	26. IV.	18. V.	54

Unlike the other Palm pest, the Rhinoceros Beetle, the Palm Weevil passes the whole of the life-cycle on the food plant. Eggs are laid, and the grubs feed and pupate on the plant; and soft moist tissues of the plant form the food of the adult weevils.

Egg.

The egg measures about $2\frac{1}{2}$mm. long by about $1\frac{1}{4}$mm.; is cylindrical, elongate-oval, the ends being slightly tapering from the middle but rounded at the extremities. The colour is creamy white. The surface is smooth and somewhat shiny. (Plate XXVIII, fig. 1.)

The mother weevil first of all gnaws a hole with the snout and either turns round or moves forward and seeks the hole with the protruded ovipositor which is intended to be dipped into the hole. Usually the hole is found after some unsuccessful attempts and then it does not take long to deposit the egg. Rarely the hole is not found and the egg is deposited on the outside. In such a case the mother turns round and devours the egg wholly without leaving any trace of it. Usually a single egg was deposited in a hole; but

2 or 3 eggs would be found near each other, each being placed in a separate hole formed for it. Rarely one or two eggs would be found on the bottom of the cage in which the weevils were kept. These were probably shoved under the pieces of stems lying on the bottom of the cage. The holes prepared for depositing the egg varied from about 3mm. to 5mm. in depth and usually they did not go down perpendicularly from the surface but slightly obliquely. Eggs were thrust right into the bottom and stood erect. As the diameter of the hole was always bigger than that of the egg, they were never found to be pressed at any point. (Plate XXVIII, fig. 2.)

Eggs were deposited in the Insectary both during the daytime and at night in portions of the soft moist interior part of *Khajur* (*Phœnix sylvestris*, Roxb.) and *Tal* (*Borassus flabellifer*, Linn.) stems supplied indiscriminately. The weevils also fed on these pieces. One female laid 276 eggs in the course of 49 days and another laid 127 eggs in 46 days; also a lot of 4 females laid 213 eggs in 24 days. Below are given the records of oviposition. They explain the reason of the overlapping of broods. As oviposition continues for such a long period, practically as long as the weevil lives, all stages of the insect would naturally be found at the same time.

(1) *Specimens received from Bapatla, Madras, in December* 1909.

2 weevils emerged	—	20. XII. 1909.
2 ,, ,,	—	25. XII. 1909.
7 more ,,	—	25. XII. 1909 to 7. I. 1910.

Of these 7 were males and 4 females. All these were kept together and fed.

The following eggs were laid by the 4 females :—

3 eggs	——	7-8. III.
2 ,,	——	8-9. III.
6 ,,	——	9-10. III.
6 ,,	——	10-11. III.
4 ,,	——	11-12. III.
2 ,,	——	12-13. III.
4 ,,	——	14-15. III.
11 ,,	——	15-16. III.
3 ,,	——	16-17. III.
7 ,,	——	17-18. III.

Palm Weevil grub burrowing in Palm-stem.

The following eggs were laid by the 4 females :—(*contd.*)

7	eggs	——	18-19. III.
14	,,	——	19-20. III.
16	,,	——	20-21. III.
15	,,	——	21-22. III.
60	,,	——	22-24. III.
25	,,	——	24-26. III.
11	,,	——	26. III. 10 A.M. to 6-30 P.M.
10	,,	——	26. III. 6-30 P.M. to 27. III. 6 A.M.
4	,,	——	27. III. 7 P.M. to 28. III. 6 A.M.
3	,,	——	29. III. to 30 III.
3	died	——	20. III.
5	,,	——	24. III.
2	,,	——	31. III.
1	,,	——	4. IV.

(2) 1 male and 1 female emerged 4. IV.

They were put together and the following eggs were laid :—

2	eggs	laid	——	6-7. IV.
1	,,	,,	——	7-8. IV.
5	,,	,,	——	8-9. IV.
14	,,	,,	——	9-11. IV.
12	,,	,,	——	11-13. IV.
5	,,	,,	——	13-15. IV.
11	,,	,,	——	15-17. IV.
21	,,	,,	——	17-20. IV.
16	,,	,,	——	20-21. IV.
11	,,	,,	——	21-22. IV.
7	,,	,,	——	22-23. IV.
8	,,	,,	——	23-24. IV.
4	,,	,,	——	24-25. IV.
7	,,	,,	——	25-27. IV.
No eggs up to				29. IV.
5	,,	laid	——	29. IV. to 1. V.
11	,,	,,	——	1-3. V.
32	,,	,,	——	3-6. V.
5	,,	,,	——	6-8. V.
9	,,	,,	——	8-10. V.
12	,,	,,	——	10-12. V.
17	,,	,,	——	12-14. V.
14	,,	,,	——	14-16. V.
5	,,	,,	——	16-17. V.
5	,,	,,	——	17-19. V.
18	,,	,,	——	19-21. V.
19	,,	,,	——	21-25. V.
The female died			——	26. V.
The male died			——	3. VI.

(3) 1 female emerged 8. IV.

She was put in with a male of a previous date and laid the following eggs :—

5 eggs laid	——	9-10. IV.
1 egg ,,	——	10-11. IV.
4 ,, ,,	——	11-13. IV.
No eggs till	——	20. IV.
2 eggs laid	——	21. IV.
2 ,, ,,	——	21-22. IV.
5 ,, ,,	——	22-23. IV.
3 ,, ,,	——	23-24. IV.
None	——	24-25. IV.
5 eggs laid	——	25-27. IV.
No ,, ,,	up to	1. V.
2 ,, ,,	——	1-3. V.
21 ,, ,,	——	3-6. V.
7 ,, ,,	——	6-8. V.
10 ,, ,,	——	8-10. V.
5 ,, ,,	——	10-12. V.
8 ,, ,,	——	12-14. V.
7 ,, ,,	——	14-16. V.
4 ,, ,,	——	16-17. V.
2 ,, ,,	——	17-19. V.
9 ,, ,,	——	19-21. V.
25 ,, ,,	——	21-25. V.
The female died	——	26. V.
The male died	——	10. VI.

It is not exactly known how and where the eggs are laid in nature. From what has been observed it seems certain that the part chosen for oviposition should be such as the weevil can easily probe with its snout and as will supply a moist and more or less soft pithy tissue to the hatching young grubs. The beetles themselves also want such tissue to feed on. Therefore wherever such tissue is exposed either by tapping or cutting of the stem or boring of other insects, the weevils would be attracted to feed if not to lay eggs, and if there is food available for the grubs it would be natural for them to lay eggs. The American Palm Weevils are said to feed freely on decaying sap or fruit such as mangoes or bread-fruit and on the rotten tissues of the palm cabbage and pith to which they are attracted by the smell of fermenting juices. They are attracted to a palm tree which is cut down or wounded and are thus trapped. They also come to the cut ends of sugar-

cane sets and lay eggs there. The Palmetto Weevils, too, are said to be attracted to a cut palmetto and are caught in large numbers in this way. The Indian Palm Weevils are also similarly attracted, and, therefore, when the soft part of the stem of date palms just below the head is exposed in the process of tapping, they will come to feed and will also lay eggs there. But where the dried surface of the cut is removed every day in order to maintain the flow of sap, most probably the eggs have no chance of hatching; because they are not laid very deep and will either be removed with the cut surface or injured; also they take 3 to 4 days to hatch in summer and a longer time in winter.

Where trees are trimmed and stripped of leaves which are not yet dry enough and fit to be removed, much of the yet unhardened part of the stem is exposed and weevils could come and lay eggs there. Mr. A. S. Kearns, an *abkari* (excise) officer in Mysore, says that trees are attacked within a few days of being stripped of leaves. Dr. C. A. Barber, Government Botanist, Madras, states that the beetle enters the inflorescence when the spathe opens and lays eggs there. Whenever any soft tissue is exposed, it may be taken advantage of by the weevils to deposit eggs.

About the month of May the Rhinoceros Beetles come out, fly to the tops of palm trees and burrow down exactly at the base of the soft and yet unopened middle leaf or leaves. The hole is about $1\frac{1}{2}$ inches in diameter and loosely filled with the chewed up fibres which are thrown out in the operation of boring. It makes a coveted and ideal hiding place for Palm Weevils, which thus get an easy access to the soft heart of the tree. From an examination of several trees burrowed by the Rhinoceros Beetle it seems extremely probable that many trees are attacked in this manner by the Palm Weevils.

While such wounds afford vulnerable spots for the deposition of eggs, it is probable that normally eggs are laid in soft parts of the stem at the base of the whorl of leaves.

The young grubs hatch out of the eggs by bursting the shell which is not hard but membranous. First of all a slit is cut open

by the mandibles and then the peristaltic movements of the body burst the shell. The colour of the egg hardly undergoes any change, being only dimmed a little and losing the gloss.

Larva.

The newly hatched grub (Plate XXVIII, fig. 3) is about 3 mm. long and is uniformly pale yellow or yellowish white in colour. The head becomes brown in the course of about 5 hours. The body is pale yellow, soft and fleshy, and wrinkled transversely. The margins of the anal segment are slightly curved upwards forming a small concavity above. There are no legs of any kind. The appearance of the larva is practically the same in early as well as grown-up stages. Full grown larvæ reared in the Insectary measured about 60 to 65 mm. in length and were about 20 mm. thick. Larvæ collected from trees outside sometimes measure about 3 inches (75 mm.) or more. The head is brown. There is a similarly coloured plate on the prothorax. The body is wrinkled and capable of being contracted or expanded to a great extent. It is by alternate contraction and expansion of the body that the grub moves quickly forward or backward in the tunnel it forms. The colour is pale yellow. Only two pairs of spiracles are well developed, *viz.*, the first pair on the prothorax and the 9th pair. These ninth spiracles are placed not on the sides like the other pairs but on dorsal side inside the margins of the anal concavity. The other spiracles, *i.e.*, the pairs 2-8 on the first seven abdominal segments are minute and not well developed. The grub is curved a little ventrally, the back being humped to some extent. When the body is contracted, the hump becomes prominent. (Plate XXVIII, fig. 4.)

When the grub hatches, it finds itself in close proximity to its food and it begins to feed forming a tunnel which increases in calibre as the larva grows. The whole larval life is passed in this way. In the Insectary the grubs were placed in small artificial holes in pieces of the interior portions of *tal* and *khajur* stems and they burrowed inside and fed. It was found that when they were placed in pieces which consisted almost wholly of thick fibres, they could hardly

PALM-TREE ATTACKED AND DESTROYED BY WEEVIL.

feed and would come out. They fed well on pieces which were soft and pithy or contained immature soft fibres and few or no developed fibres. The grubs are not in the habit of injuring each other. Several were kept, both young and grown, in the same piece of stem. They met each other, and two or three would often be found side by side in the same hole, but none was hurt.

The damage which is done to trees is done by the grubs only. In affected trees usually grubs and cocoons with or without pupæ will be found. The weevils after they emerge from the cocoons usually leave the tree and go elsewhere, but may return for feeding and ovipositing if opportunities occur. The damage caused by the feeding of weevils is insignificant. The grubs may be found at any part of the affected tree; this depends on where eggs are laid.

The Superintendent of the Government Horticultural Garden in Lucknow in reporting the damage to date palms caused by the larvæ of the Red Weevil, wrote as follows:—

"The tree from which these (grubs) were taken blew down a few days ago. At the base and for half the height of the stem, it was quite decayed and full of the refuse created by the larvæ of the beetle. The upper part was fresh and the leaves green and, until the tree came down it was not noticed to be in bad condition."

The Superintendent of the Public Garden, Saugor, C. P., found grubs and cocoons in the middle of the stem of a date palm about 10 feet high.

A palm tree (figure) measuring 11 feet from near the roots to the top of the stem, was found dying in a village near Pusa, and from near the neck a thick resinous secretion was found to have oozed out and hardened on drying. The tree was felled and while falling it broke into two pieces a little above the middle. Numerous *Rhynchophorus* grubs, young as well as grown, were found riddling the interior of the stem, and they were found to have come down from the top to about 4 feet from the roots. The damage was greatest at about a foot below the top where hardly any appearance of the stem was left inside, the whole being a rotten mass. The entire top shoot came out at a pull, because the whole base was

chewed up. There was no mark of the larvæ having gone down into the stem from the leaves, or through the leaf stalks.

On removing the leaf sheaths from the place where the resinous secretion was formed, numerous holes were found and the secretion was found to have come out from these holes. Many of the holes seemed to have been made by the larvæ which happened to come to the peripheral region in the course of their boring. The secretion was the juice of the stem which had oozed out through these holes, collected at the base of the leaf sheaths and become dry. A few cocoons were also found. The grubs eat the soft pulpy interior and usually come to pupate in the peripheral region where the fibres are the thickest and most numerous.

It could not be determined from an examination of the tree how eggs had been laid ; holes made for oviposition would be very small and could not be noticed in a decaying and dying tree. It seems the weevils do not require any special crack or cut for laying eggs in, as they can easily creep down the leaf sheath and reach the soft base of the top shoot, then gnaw a small hole with the snout and thrust in the egg. Most probably eggs were deposited in this manner, principally in the soft parts near about the neck of the tree. The larvæ which hatched went down boring the stem. When about to pupate they came to the peripheral region and formed cocoons with the fibres there. Cocoons were formed near about the places where there were holes in the stem. Many of the holes might have been caused by the emerging weevils. The tree was in an uncared for state, as such trees usually are, with all old leaf stalks and leaf sheaths on.

The larval stage was seen to occupy a period of from 25 to 61 days, the general average period being about 30 to 35 days.

Pupation.

When the grubs are full grown and about to pupate, the colour changes to a deeper yellow. They build an oval cocoon inside the stem by arranging the long stiff fibres spirally. The cocoon is about 60 to 65 mm. long and about 25 to 30 mm. thick and is

closed on all sides (Plate XXVIII, fig. 6). It exactly fits the space in which it is formed. Pupation takes place in this cocoon. The pupæ which were reared from eggs in the Insectary measured about 30 to 32 mm. The pupa is of the ordinary curculionid type. The snout, legs, antennæ and wing cases are neatly and symmetrically folded on the venter. The pupa has a general resemblance to the weevil. The colour is yellow (Plate XXVIII, fig. 5). In the Insectary it took from 18 to 33 days for the grub to come out as a perfect beetle from the day it prepared the cocoon. The general average period is about 25 days.

The Adult Weevil.

When the weevil attains the adult stage by casting off the pupal skin, its colour is pale yellow and the whole body and limbs are soft. It takes about 4 days for the limbs to harden and the colour to develop into brown. The weevil does not emerge from the cocoon before the limbs are properly hard and the colour turns brown. It comes out of the cocoon by breaking open one end.

The weevils are red or brown insects with a prominent snout (Plate XXVIII, fig. 7). The males can be easily distinguished by the presence of a tuft of hairs on the more straightened snout (Plate XXVIII, fig. 8). The snout of the female is a little more slender, a little bent and devoid of any tuft of hairs (Plate XXVIII, fig. 9). In copulation the male is on the back of the female which may be feeding at the time. In the Insectary they coupled any time during the day and night. The period of copulation was short, lasting only a few minutes. The longest period noticed was 7 minutes.

The weevils are shy of light and always try to hide themselves in dark corners and under rubbish. In the Insectary a mass of straw was supplied and they used to live hiding in this mass. Pieces of *khajur* and *tal* stem used to be supplied as food and they fed during the night as well as during the day. If they found a crack or fissure in the pieces of stem supplied, they would creep into it although hardly able to enter with ease. Several pairs were kept separately and each pair coupled many times. The weevils are

capable of flying to great distances. In the Insectary those which escaped from the cage would be on the wing for 2 or 3 minutes at a time and then fall with a thud. While they fly a loud heavy droning sound is produced. In the Insectary the weevils lived for about 50 to 90 days. They required a constant supply of food. They fed by thrusting the snout into the piece of stem of *khajur* or *tal* supplied and would reduce the surface into a chewed-up, broken and mutilated condition. When disturbed the weevils fold up the legs and pretend to be dead.

Preventive and Remedial Measures.

[*In this connection see Indian Insect Pests, page* 209.]

Remedial measures are directed to two ends : firstly, to prevent egg-laying in trees which are yet unaffected ; and secondly, to destroy the insect whether found in adult or larval stages.

The trees should be left as far as possible in the natural condition and should not be stripped of leaves which should be allowed to dry and fall off themselves. All cracks or wounds including that caused for tapping should be coated with a layer of clay or daubed with tar and fine sand or treated in such a manner that the weevils cannot reach the soft tissue. The hole bored by the Rhinoceros Beetle should first of all be probed with a stiff iron wire hooked or barbed at the end, so as to pierce and extract the beetle and then stopped by plugging with dry grass or any such stuff in order to prevent access of the Red Weevil. Mr. L. C. Brown of the Federated Malay States, recommends putting a few drops of "Zotal" in the cavity and smearing the entrance to the hole with the composition with a brush ; he says it does not harm the tree but gives a decided stimulating and recuperative power to it and prevents other beetles from making use of the hole. No felled trees or stumps should be left which can afford breeding places ; the weevils are sure to come and lay eggs in them, and the weevils which thus develop will affect other trees. Felled trees are recommended to be sunk in water or buried deep underground. Cut stumps or soft palm tissues are used in the West Indies to

attract the weevils and trap them ; they are visited in the morning and the weevils are collected and killed.

When any tree is attacked, if the attack is seen in time and is light, the part is cut open and the grubs extracted, the wound being treated as suggested above. This may save the tree. But as a rule affected trees should be cut down, split open and the insects collected and killed, and then the tree burnt. The stump, or any soft part of the tree, should not be left but all should be destroyed.